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NOTICE.

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EARWIGS.—I.

By E. A. Butler.

THE family of British Earwigs is a small one, numbering at present six species; no more than two of these, however, are common, and probably most people know only one, which to them therefore ranks as *the* Earwig. This is the insect whose scientific name is *Forficula auricularia*, the well-known species which is to be found abundantly everywhere. We will take this common and easily obtained insect as the type of the group, in the hope that our readers will catch one, and follow with us the outline of its form; the deviations of structure which the other species present will then be easily appreciated. The common Earwig is so well known that only a few words will be necessary to add accuracy of detail to the rough general idea of its shape and structure that is already in everybody's mind. Exclusive of the forceps at the end of the body, which vary considerably in size, the common Earwig has a length of about half an inch. It has a flat, rounded, reddish head, carrying a pair of 15-jointed antennæ, at the base of which, but outside them, are the black, oval, compound eyes, which lie flat and do not project from the head. No ocelli, or simple eyes, are present.

Behind the head is the thin, flattish, shield-like cover of the first segment of the thorax, which projects at the sides as a kind of flap, and behind laps over the front of the wing-covers. It is dark brownish-black in the centre, with pale yellowish borders. Behind this is a pair of pale yellowish-brown wing-covers, or elytra, which are thin and flexible, and lie flat on the back, but bend down at the sides like those of the house-cricket; when closed they exactly meet, with a straight junction along the middle line. Their hinder edge in reality forms almost a straight line across the body, but at first sight this does not seem to be the case; they appear to have two projecting pieces in the middle of this edge, which remind one of the shape of the two halves of the cloven hoof of a cow, save that they are almost flat. These, however, are not part of the wing-covers at all, as may easily be proved by raising the latter with the point of a needle, when these projections are seen to be in no way attached to them; they belong in fact to the wings, which, except for this part, are entirely concealed under the covers. The wings and their covers when closed, as one usually sees them, are so short that they conceal little more than the hinder part of the thorax, and thus leave almost the whole of the abdomen exposed.

The abdomen is by far the largest part of the insect, being the longest, the widest, and the deepest, so that when the Earwig walks the fore part of the body is elevated a little on the legs, while the abdomen almost trails along upon the ground (Fig. 1). Nine distinct segments can be seen above in the abdomen of the male, but only seven in the female; they are of a mahogany-brown colour, more or less tinged in places with black. To the hindmost segment are attached the forceps, by which feature alone Earwigs

Fig. 1. Position of Earwig when walking.

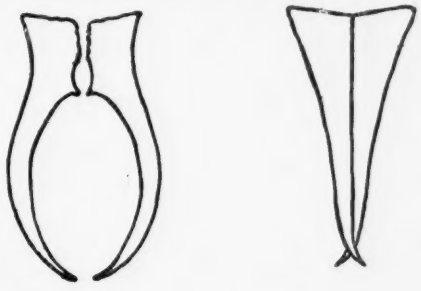

Fig. 2. Forceps of Earwigs.—A, male; B, female. Shown in the position they take up after death. Magnified six diameters.

can be distinguished from all other insects. They differ considerably in shape in the two sexes (Fig. 2); in

the male each forms a curve, so that when closed they constitute the boundaries of an open oval space. On the inner edge, near the base, they are ornamented with small, irregular, tooth-like projections, and beyond these on each side there is a solitary but much larger one, just where the "legs" of the forceps begin to diverge. The forceps are strong, stout organs, of a yellowish-brown colour, with the teeth blackish; they are highly polished, and exhibit in different specimens considerable variety as to length and degree of curvature. Sometimes, through accidents in early life, they become twisted, or otherwise deformed. Those of the female are simpler and less elegant. They do not curve outwards when closed, but lie side by side as far as the tip, where they cross one another slightly. In both sexes they are habitually carried widely open, and pointing obliquely upwards. The six legs are yellowish and almost transparent, and are composed of the usual parts.

Such is the external aspect of the common Earwig, from which we may now pass to consider the structure and manipulation of the wings, which are by far the most beautiful part of the insect, and deserve special attention. It is very seldom that the wings can be seen when the Earwig is alive, for they are used chiefly by night, and one can have no conception of their size, or of the beauty that lies concealed under their covers, if one merely watches the running insect; indeed, it is difficult under such circumstances to believe even in their existence. To examine the wings properly the Earwig must be killed; this may be done instantaneously, and without damage, by plunging it into boiling water. Let it then be placed on blotting paper to dry it, and afterwards laid full length upon some hard surface. Then let the wing-covers be raised and separated a little towards the right and left; a neat little package will thus be found under each, which, strange as it may appear, is really a beautiful transparent wing, folded up into extremely small compass. By dint of care and patience it may be opened fold after fold till its full extent is exposed, when it will be found to spread over an area some seven or eight times as large as the cover under which it was hid.

The complete unfolding of the wing is a delicate operation, and must be managed methodically. The following method will succeed very well if the directions are carefully attended to. The wing-cover having been removed by raising it behind and then gently snipping it off in front with a fine pair of scissors, the folded wing lying beneath may be carefully seized with forceps, lifted up and snipped off in the same way as the cover, or it may be gently pulled away from its attachment. As it is too small to be conveniently manipulated unless when fixed to some support, a card should be provided, on which may be placed with a small camel's-hair brush a very little gum tragacanth, made by soaking a small piece of the solid gum in water till it is of the consistency of rather thick paste. The gum will very quickly dry if only small quantities are used, and leave no trace behind; it should not be put on the card till the wing is ready to be transferred to it. The wing packet may now be placed gently on the gum with the *upper* surface *downwards*. In a few minutes the gum will be dry and the wing will thus be fixed (Fig. 3, A). By aid of a needle it will now be found that there are two layers of material folded upon one another like the leaves of a book. One of the edges will be observed to be straight, the other curved; the straight one is where the fold occurs. By aid of the needle the flap may be lifted and turned over along this hinge and pressed down on to another small supply of the gum, which may be put on just in time to receive it. The wing will now of course be twice as broad as before, and will present the appearance shown in Fig. 3, B. It will now become evident that the part that has been turned

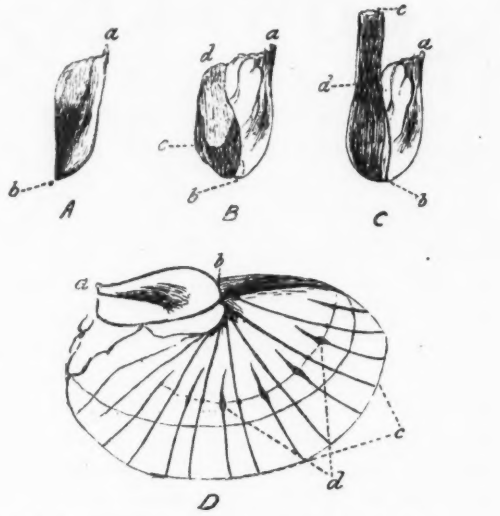

Fig. 3. Four stages in unfolding Earwig's left wing. The small letters represent the same parts in all the figures. Magnified six diameters.

back itself consists of two layers, bent upon one another not in the same direction as before, but with the hinge lying *across* the wing at its upper end. The uppermost flap may easily be bent back across its hinge, when the wing will appear as in Fig. 3, C. This last piece should not be fastened down, but simply pressed back. Now comes the most difficult part of all. The long smoky part which occupies the whole of one side of the wing as it is now displayed consists of a thin membrane strengthened by leathery rays, and arranged in a number of longitudinal folds, and the whole is bent back upon that part of the wing that is attached to the card at the end opposite to the position of the former hinge. It may be lifted at *d*, and as it is raised the membrane gradually opens itself out in all directions. The outer edge may be gently pushed back on to the card, on which another small supply of gum has just been spread, and if care be taken to keep the narrow dark triangle shown at *b* (Fig. 3, D) in the same line as the original outer boundary of the wing, the rest will fall pretty easily into its place, and become neatly spread out on the card. If it does not settle on the gum quite smoothly the wrinkles may be got rid of by using the needle as a sort of rolling pin, and rolling it out from the stouter towards the weaker margin of the wing. This last operation requires care, as the membrane is very easily torn. We now have the whole wing expanded with its under surface uppermost. It will keep any length of time in this position.

To understand why the wing always folds in precisely the same way, attention should be directed to the membranous part last exposed. From the joint *b* (Fig. 3, D) nervures will be seen radiating like the framework of a fan. About half-way down its length, each dilates into a minute swelling, and as the individual rays diverge more and more, other shorter ones are seen to spring up alternately with them, passing outwards to the edge of the wing, but not reaching the hinge aforesaid. These also have each a similar but much larger swelling, the whole set forming a row parallel to the hind margin of the wing (*d*, Fig. 3, D). The membrane having been folded like a fan

along the lines of the radiating nervures, all these little leathery spots are brought up side by side, and the whole collection is then bent across at this spot, thereby reducing the membrane to half its length. A transverse nervure running parallel to the hind margin, but nearer to the line of bending than to it, serves to give stability to the wing when fully expanded. The rays are the divisions of the anal nervure, the area of which in most insects forms only a small part of the wing nearest the body, but in the Earwig has so far expanded and encroached as to constitute almost the whole wing.

The wing readily closes of its own accord at the transverse bends, in virtue of its own elasticity; but obviously this must be overcome in opening by some external force, and it is just here that the forceps at the end of the body come in usefully. The Earwig is said to use its forceps to aid the operation, turning them over its back to do so. There is great difficulty in verifying this statement, owing to the nocturnal habits of the creature and its general disinclination to use its wings. If the wings are opened artificially, the Earwig will often go for hours without closing them, and then when it finally does so, probably the experimenter is absent. It is said also to use the forceps in closing the wings, though from the nature of things it would seem that they would be less required then. There are some foreign species whose forceps are as long as the body, and it is difficult to see how these can make such a use of their exaggerated tail appendages. The forceps are of course weapons of offence and defence as well, and are probably quite as effectual by giving a terrifying appearance to the insect as by being actually used for pinching.

The Earwig is one of those insects whose metamorphosis is incomplete, like the cockroach, cricket, and bed-bug. The eggs are little oval yellow things; they may sometimes be found under stones, &c. De Geer has left an account of a mother Earwig which he found with a batch of eggs, which implies that these insects, contrary to the general practice, show maternal solicitude. He placed the eggs in a jar, scattering them over the surface of some earth it contained, and then put the mother in. She immediately set to work picking up the eggs with her jaws, and conveyed them all to the same spot, where she remained jealously guarding her treasure till the young were hatched. And even then the cares of maternity were not over, for the young ones clustered round their mother, running in and out between her legs and under her body, like chickens under the mother hen. When first hatched, the young are quite white, except for the eyes and jaws, which are reddish. They soon darken, however, into a tolerably uniform pale brown. They are very similar in shape to the adult, but have no wings or wing-covers, while their antennæ also have fewer joints, and their forceps are more simple in form. After several moults, each accompanied by an increase in size and a darkening in colour, they appear, like the cockroaches and crickets, with the outline of wings sculptured on the thorax; in this form they are called nymphs or pupæ. The next moult yields the perfect and mature insect, with the full number of joints to the antennæ, wings, wing-covers, and forceps all perfect, and the sexual organs fully developed. At each moult the insect is soft and white immediately after casting the skin, but gradually becomes harder and darker by exposure.

Earwigs are extremely voracious; they are chiefly vegetable feeders, and are especially fond of the corollas of flowers, so that they are a great annoyance to gardeners by nibbling the flowers and thus spoiling their symmetry. Their method of procedure can be easily watched by putting a few specimens in a glass jar and supplying them with flowers such as the garden nasturtiums (tropæolums). The jaws work in the same way as those of cockroaches, the palpi being in incessant motion all the time. Earwigs can run up and down the perpendicular sides even of a glass jar with perfect ease, an accomplishment very essential to their well-being, as their favourite food so often lies up on the end of a tall stalk. Hence, one can account for their presence in sunflowers and other tall flowers, without assuming that they have flown thither. They habitually rest with legs widely spread out, and this, no doubt, helps to give them a firm foothold. On the other hand, however, as everybody knows, they are extremely ready to relax their hold and drop at once to the ground, if disturbed. They are fond of the darkness, and it would almost seem as though light were painful to their eyes, for they habitually endeavour, when disturbed in the daytime, to poke their heads into some obscure corner.

Earwigs, although they make a good deal of mess in the places they frequent, by the abundant accumulation of their excrement, are yet not in themselves of uncleanly habits, but are in person usually scrupulously clean. If watched for a little while they will be seen cleaning themselves as a cat would do, putting the forefoot up to the mouth and then rubbing it round the head; the hind foot will also sometimes be bent round underneath and brought up to the mouth in the same way, just as we described in the case of the Book-louse, and after some tremulous movements with the jaws and palpi, it will be stroked down the back several times, evidently with the intention of removing particles of dust, &c. There is a surprising air of intelligence about them as they perform their ablutions, and a steady, business-like application to the work, which is highly amusing. A similar appearance of a power of resource and vigour of purpose are often to be seen while they are feeding, especially when an Earwig, reaching up to a flower above its head and almost too high for it, gives it little tugs with a jerk of the head, like a horse pulling hay out of a rack.

(To be continued.)

INTERNATIONAL YACHTING.

By Richard Beynon, F.R.G.S.

THE ascendancy of Great Britain over the other maritime nations of the world, in the size and number of her merchant vessels and the skill of her shipbuilders, is undoubted. There is one department of our marine, however, in which the place of supremacy is very closely contested by other countries. British yachts are not allowed to retain a position of pre-eminence among the pleasure craft of the world without encountering the powerful rivalry, first of the United States, and secondly of France. In discussing the subject of International Yachting it would be well to consider first the different types of yachts obtaining in the Eastern and Western Hemispheres. It must be remembered that the law of the survival of the fittest holds good in yachting, and the kinds of boats used in English and American waters are those which are best adapted for the special conditions of water and weather they have to encounter. In the United States, yachting is chiefly prosecuted along the Atlantic seaboard, and as the prevailing winds are westerly, it follows that Americans have the shelter of their eastern coast line to shield them from high westerly winds, and to ensure them comparative calm water for their sport. In England it is very different; the south and west coasts are those most affected by yachts-

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men, and these are exposed to the full force of Atlantic seas. Hence it follows that the English yacht must be a boat of greater stability than the American type, one that is able to make good weather in a rough seaway, and need not always run to port on the approach of half a gale of wind. This structural difference between British and American types is much accentuated when an international race comes off. The American type is possessed of greater stiffness than English yachts usually are, and consequently can carry greater sail spread. This stiffness holds good only through the ordinary inclinations at which yachts are sailed. At an angle when the British deep-keel boat is perfectly safe, the stability of the centre-board boat vanishes altogether. Thus the celebrated *Volunteer* could carry an enormous spread of canvas until an inclination of 76° was reached, when its stability vanished. The *Thistle*, however, now the *Meteor*, is practically uncapsizable. In ordinary weather the centre-board has the advantage of being able to carry more canvas on a more even keel than the English type of yacht, and at the same time possesses the additional advantage of making less leeway without increase of wave-making resistance. The superiority of the British yacht needs rough weather to demonstrate it. Safety is assured where the American type would be absolutely unsafe. A glance at the loss of life attendant upon British and American yachting shows the truth of this statement. Of course it is impossible that English yachting should be prosecuted with the ardour so characteristic of yachtsmen without disaster of some kind. During the three years ending June, 1887, the average loss of life from yachting accidents was ten. The season 1887-8 gives a loss of eleven lives, while 1888-9 shows a reduction of this number to four. The mishaps in question were produced either by collision or stranding. There is no case of capsizing. The American record compares unfavourably with this. Taking the year 1887-8 we find some serious cases of capsizing, which point conclusively to a woful lack of stability. The sloop *Mystery* capsized, and twenty-five lives were lost. The *Gracie* was thrown on her beam ends, and one person was drowned; while the *Olivette* capsized in Newark Bay, and six lives were lost. As showing the risk attendant upon yachting in "shallow" boats of the "skimming dish" type the above figures are conclusive. The *Mystery* was 29ft. 3in. by 11ft. 5in., with a draught of 2ft. 5in.; while the *Gracie* was 70ft. by 21ft., with a draught of 6ft.

Most of the disasters occurring among British yachts are those which happen to small vessels of but few tons. The larger British yachts enjoy an immunity from disaster producing loss of life, that is most remarkable, only one life being lost from boats exceeding 40 tons during the five years terminating with the yachting season 1888-9.

The international races between British and American Yachts, besides proving of the greatest interest to the naval architect, stir a national enthusiasm which stimulates invention on both sides of the Atlantic. Their present discontinuance is to be regretted as the inevitable result of the conditions under which the American Cup is offered for competition. English yachtsmen are asked to send the particulars of the boat they propose to enter for the contest, and the nature of the details enables the Americans to build a boat on lines which they think an improvement. Or some three or four boats may be built and the best selected to compete with the foreigner. When the enemy is placed in possession some ten months previously of the length, draught, extreme breadth, breadth on the load water line, and the register tonnage of the challenging craft, he is supplied with data which place him at a very great advantage indeed. To such stringent conditions as these, British yachtsmen can hardly be expected to concede, and until some important modification is arranged international competitions for the possession of the American Cup must cease.

The conditions attached to the international race which our Royal Victoria Yacht Club attempted to arrange are much fairer. The challenger needs only to send an approximate specification of the design of the vessel he wishes to enter. The length on the load line must be stated, and the rating, but a margin of variation of 5 per cent. on the length and 10 per cent. on the rating is allowed.

The American excess of patriotism, which amounts to exclusiveness, makes itself felt in other directions besides excluding competitors from the chance of winning the American Cup.

The protectionist policy, of which the McKinley Tariff Act is typical, affects American ship-owners, and more especially yacht-owners, very seriously. The design of the measure was to foster native ship and yacht building by levying a duty of 50 c. per registered ton every time a foreign-built but American-owned vessel enters a United States port. Visiting yachts are, to a certain extent, exempt from this impost, but if their visit is prolonged over six months then they become liable under the Act. How hardly this tax will fall upon American citizens a single example will show. Mr. Frederick Vanderbilt purchased at Cowes, during the present season, the steam yacht *Conqueror*. Each time he enters one of the United States ports he will have to pay a tax of £40. An American contemporary thus explains the working of the Act so far as visiting yachts are concerned. "If Lieutenant Henn should pay a friendly visit in the *Galatea*, as he did in 1886-7, arriving in August of the former year and staying until October of the latter, he would be compelled to pay duty on his yacht—about 1800 dollars—and, besides this, a tax of 80 or 90 dollars at every port at which he called, besides being liable to a fine of 100 dollars each time he got underway."

Such a measure as this can hardly tend to foster friendly rivalry between British and American yachtsmen, and must inevitably decrease the enthusiasm for the sea and the improvements in shipbuilding which it was intended to foster.

So far as present prospects are concerned international yachting in the future will be confined to contests between British and French vessels. Yachting is quite a new sport in France, but its growth, though rapid, has been phenomenal. It is not so very long ago that the *Eulalie* of 20 tons, built at Havre, was the sole representative of this type of craft in France. Now the popular interest in the nautical pastime is such that a highly successful weekly journal, "Le Yacht," is published, and French yachtsmen are longing to measure their strength with foreign competitors. An energetic and influential committee, formed to further yachting, resolved to offer, in the name of the Comité du Yacht Français, a challenge cup styled "Coupe de France," as the prize of an international race to come off in French waters during the racing season of 1892.

The friction between England and the States relative to yacht racing has given a decided check to the multiplication of large yachts, and both in England and America the feature of the present season has been the development of small yacht racing. The 90ft. sloop which engrossed so much attention along the Atlantic seaboard has gone out of fashion, and the largest class now is the 46ft. boat, which corresponds to the English 20 tonner. The Pacific and the North American lakes have copied the movement initiated in the eastern nautical centres, and nothing but the revival of international racing will bring the big boats into favour again. Whether the present friction will shortly

be smoothed over remains to be seen, but the spirited action of our Gallic neighbours ensures that in one direction at least international yacht racing is not altogether a thing of the past.

SWIMMING ANIMALS.

By R. Lydekker, B.A.Cantab.

(*Continued from page* 168.)

THE Divers, Auks, and Grebes are, with the exception of the Penguins, those birds which appear to have been most profoundly modified for a life in the water, being equally at home both on and below its surface. In these birds the short legs are placed so far back that when on land the body is carried in a more or less nearly erect position, as we may observe in the Guillemots and Puffins of our coasts. Although the legs themselves are very short, yet the toes are elongated, so as to convert the feet into very powerful oars. Most of these birds look exceeding awkward when on land, and as they use both their feet and wings in diving, the water is undoubtedly the element in which they are most at home. Speaking of the Red-Throated Diver of Northern Europe, Mr. Dresser observes that "it swims low down in the water, and when uneasy or alarmed will submerge its body below the surface, leaving only the head and neck in view. When it dives it vanishes beneath the surface without noise or flutter, and propels itself along with its wings as well as its feet, frequently remaining for some time before it emerges to view again."

The most remarkable modification which birds have undergone for the purposes of an aquatic life is, however, presented by the Penguins of the Southern Ocean. These grotesque birds, some of which attain a very large size, are even more upright than the Puffins, and when arranged in lines on the cliffs of the Antarctic lands have been compared to regiments of soldiers. Their short wings, which are of course utterly useless for flight, and have but a very limited range of motion, are converted into flipper-like paddles, covered with short bristly feathers, their only use being as additional swimming organs. We have here, therefore, an instance of an organ originally modified for an especial purpose—flight—subsequently undergoing a kind of retrograde modification for a totally different use, although still retaining the structural peculiarities which it presents in ordinary birds. Certain features in the structure of the leg of the Penguins suggest, however, that these birds belong to a very primitive type.

We must not conclude our notice of swimming birds without reference to the extinct *Hesperornis*, of the Cretaceous beds of the United States. This remarkable bird, which was nearly six feet in length, shows evidence of its relationship to reptiles by the retention of a complete series of sharp-pointed teeth in both jaws. In the structure of its bones it appears to come nearest to the Grebes and Divers, but it differs from all the swimming birds in having lost (so far as can be determined) all traces of wings; and thus affords one of several instances where species, long extinct, are in certain respects more specialized than any of their living relatives.

Our remaining examples of Swimming Animals are taken from the class of Mammals, or Quadrupeds, as they are often popularly, though inconveniently, termed. And we shall find that in certain members of this group the adaptation to an aquatic life has been so complete as to have led to the loss of all external features characteristic of ordinary members of the class, and has thus induced the erroneous popular belief that the animals in question are really fishes.

In several groups of Mammals we find that a few species, or genera, have been more or less modified so as to become expert swimmers and divers. Instances of these are afforded by the Australian Duck-Bill (Knowledge, 1890, p. 84) among the egg-laying Mammals, the Otter among the Carnivores, the Beaver and Water-Vole among the Rodents, and the Hippopotamus among the Ungulates. Since, however, none of these depart very widely from the normal type of structure, we may pass to the consideration of two groups, in which all the members have undergone more or less profound structural alterations solely and simply for the purpose of swimming.

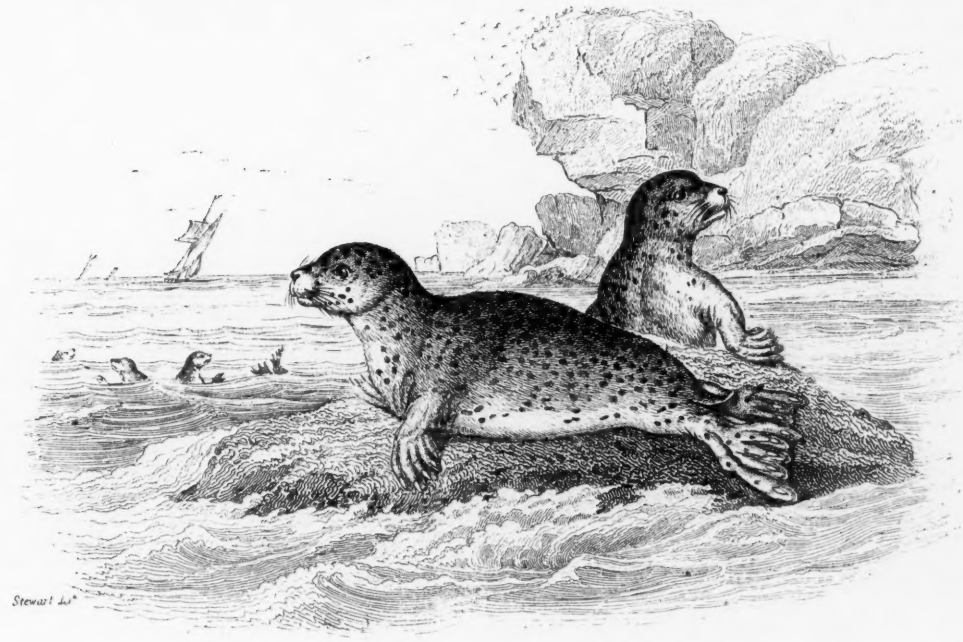

Fig. 7.—The Common Seal.

The first of these groups is that of the Seals and Walruses, which form a special division of the Carnivores. Through the spe-

cimens exhibited from time to time in the Gardens of the Zoological Society, most of us are more or less familiar with the external form of the Seals (Fig. 7), and have also witnessed the exceeding gracefulness of their evolutions in the water. In all Seals the limbs are very short, and by the complete webbing of the toes are converted into paddle-like organs. Although the amount of modification is greater in the hind than in the fore limb, yet in both the several digits of the feet still retain their external distinctness. In the so-called Eared-Seals (from which the seal-skin of commerce is alone obtained) and Walruses the hind feet are turned forwards beneath the body when the animal is on land, after the ordinary manner. In the true Seals, however (Fig. 7), these feet are always directed backwards, and thus act solely as propellers in the water. All the Seal tribe are clearly very closely allied to the ordinary land Carnivores; and the Eared-Seals and Walruses indicate the mode in which such animals have undergone a progressive modification until the extreme specialization of the true Seals has been attained.

The second group, containing the Whales, Porpoises, Grampuses, Dolphins, &c., differs so remarkably from all other Mammals that it has been referred to a distinct order—the Cetacea. All the members of this group (Fig. 1) have, indeed, assumed such a completely fish-like appearance that it is even now frequently difficult to convince people that they are true Mammals. Their mammalian nature is, however, shown by their warm blood and four-chambered heart, by the circumstance that they produce their young in a living condition and nourish them by milk drawn from the udder of the parent, and also by their respiration being effected by the aid of lungs. The "spouting" of Whales as they come to the surface is, indeed, mainly due to the water of the sea being thrown up as the air from the lungs is forcibly expelled from the nostrils before the animal has quite reached the surface. We may add that the certainty that Whales are true members of the mammalian class is one of the strongest reasons against employing the term "quadrupeds" to denote that division of Vertebrates.

Although, as aforesaid, the general appearance of a Whale or Porpoise is fish-like, yet a more careful examination shows certain very important points of difference. In the first place, the tail-fin, or "flukes" as it is termed by whalers, is expanded horizontally instead of vertically. The reason for this horizontal expansion appears to be owing to the necessity the Whale is under of coming rapidly to the surface for the purpose of breathing; the upward and downward strokes of the powerful flukes being admirably suited to effect this object with the greatest speed. Then, again, the number and structure of the paddles and fins is quite different from that obtaining in fishes. Thus, a Whale (using this term for the whole group of allied animals) has only a single pair of flippers (Fig. 1), which correspond to the fore limbs of ordinary Mammals, and to the pectoral fins of fishes. These, however, although presenting certain peculiarities, are evidently modifications of the normal mammalian fore limb, and are devoid of any structures corresponding to the fin-rays of fishes. They have lost all outward trace of the digits, being completely invested in a common integument. Then, again, the pelvic fins of fishes are wanting; the only traces of hind limbs being certain rudimentary bones found deeply bedded in the flesh of some of the species (Knowledge, 1891, p. 24, fig. 2), which represent the aborted hind legs of quadrupedal Mammals. If, moreover, Whales have any unpaired fins the single one is situate on the back (Fig. 1), and its structure is quite different from that of the dorsal fin of a fish. In order to enable them to stay for long periods below the surface, the circulatory system of Whales develops a number of net-like arrangements of the vessels in which a supply of fresh blood is stored up.

It would involve too much detail to enter into the consideration of the numerous other resemblances existing between Whales and ordinary Mammals, but there can be no sort of doubt but that they are members of the class; and likewise practically none that they are descended from a group of originally terrestrial forms, the special modification having in this case been carried to a considerably greater degree than in Seals, which we know have undergone an analogous development. Naturalists are, indeed, not altogether in harmony as to the kind of terrestrial Mammals from which Whales have descended, but the probability is that such ancestral types were more nearly allied to the pig-like Ungulates than to any other type of Mammals with which we are acquainted. The Hippopotamus shows us how a pig-like animal may become amphibious, and there is no reason why a further development should not go on. It will, however, be understood that the terrestrial ancestors of the Whales have long since disappeared from the face of the earth; and it should be added that not a trace of the intermediate connecting forms has yet revealed itself to reward the anxious search of the palæontologist. The Cetacea are first known in the upper part of the Eocene division of the Tertiary period, and it thus seems quite clear that they were developed to fill the gap left in the life of the ocean by the disappearance of the Ichthyosaurs and Plesiosaurs at the close of the secondary period; the general replacement of a lower by a higher type of organization being apparently the great life-feature by which the early part of the former period is distinguished from the latter.

THE DIAMOND MINES OF SOUTH AFRICA.

By Vaughan Cornish, B.Sc., F.C.S.

THE first South African diamond was found in 1867, and during the next three years diamonds were obtained from the river workings. In 1870, the *mother rock* was found at Kimberley. This rock occurs in pipes as they are termed, round or oval funnels with a surface area of several acres, and of great but unknown depth. Some have already been excavated to a depth of 800 feet without any sign of reaching a bottom, or bed rock. The rock first worked at and near the surface is termed the yellow ground, a friable material from which the diamonds are readily extracted. When the yellow ground was worked through and the *blue rock* struck, many of the miners imagined that the deposit was worked out, and abandoned their claims. Others filled in the excavations with the *yellow*, and sold their claims to less knowing but more fortunate adventurers. The "blue" proved to be the real matrix of the diamond, the "yellow" being merely the blue rock altered by weathering, a yellow colour having been produced by formation of oxide of iron from the action of the atmosphere on the highly ferruginous rock. The blue is a volcanic rock of very peculiar character, extremely heavy, and of the structure known as *brecciated*, characteristic of a volcanic rock which has been subjected to movement after hardening. It contains boulders of all sizes up to twenty tons, and pieces of sandstone, shale, and occasionally fragments of fossil trees. A detailed study leaves no doubt that the *pipes* are of eruptive origin—a pipe being, in fact, the neck of an old volcano—and that the blue was

forced up from below, the sandstone and so forth which show evidence of aqueous action being undoubtedly derived from the material of the formerly existing rock. This point has an important practical bearing, as an aqueous deposit must be bottomed sooner or later, which is scarcely likely to occur in the case of an eruptive formation; hence the probability that the supply of diamonds will continue to hold out. The extraction of the diamonds from the blue is less readily effected than from the yellow surface material. The blue rock is first spread out on the surface and exposed to the action of the weather. The disintegration proceeds best when wet and fine days alternate, and in dry weather the process is hastened by watering the material. The change which occurs is the same as that which produced the yellow at the surface of the pipes. When the process has gone on sufficiently long, the rock is treated by the washing machinery. The lighter materials are washed away in a pulsator, and the diamonds and heavier minerals, such as pyrites and garnet, are left in a sort of mud, which is brought on to a table and carefully searched. Comparatively few diamonds are discovered during the actual mining of the rock; they are imbedded singly, and are not conspicuous objects. The general appearance of the natural diamond is somewhat like that of a piece of white gum—the brilliancy of the stone being only called out by the operation of cutting. Naturally the stones most likely to be noticed are those of large size, and it is these which are the great prizes of diamond mining, since the value of a stone rises in a very rapid ratio with the size.

Now that the mining is no longer done by private adventurers, but the whole worked under one management, it is extremely important to ensure that the workers shall not secrete the stones. The miners, when they come up at the end of their shift, are carefully searched. As the natives work without clothes it might be supposed that the searching would be a very simple matter; it is not so, however, the hair, ears, and teeth being used as places of concealment. The stones were frequently swallowed, which led to the system of keeping the native workers in compounds, which they are not allowed to leave during the term of their engagement. No spirits are allowed in the compounds, where the "boys" are well taken care of. The life, with its order, and enforced discipline, often exercises a beneficial effect on the characters of the natives, making them sober and saving. The laws against receivers of stolen diamonds are very severe, I.D.B.'s (illicit diamond buyers) being sentenced to six or even ten years' hard labour. Most of the work at the larger mines is done by contract, the company paying so much a load, and providing and housing the native labourers, who are paid by the person undertaking the contract—generally himself an experienced miner. There are about seven natives to one white man in the mines: of the whites some 60 per cent. are British, about 4 per cent. other Europeans, or Americans.

Now that the mining is carried on at great depths, the risks of accident are considerable. Till a depth of about 400 feet was reached the system of open workings was followed, but as the depth increased the falls of the blue rock became more frequent. Zulu watchers were stationed to give warning to the miners when the rock showed signs of giving way. This kind of work involving constant alertness during long periods of inaction is peculiarly trying to white men, but is admirably performed by the Zulus.

The appearance of the mines from above is that of huge craters, at the bottom of which the tunnelling and shaft-sinking commences. A depth of some 800 feet has been reached in some of the mines. The mode of descent into these huge craters is simple and expeditious, but not suited to nervous passengers. A kind of truck or tub is suspended below two wire ropes, the flanged wheels, which are, of course, above the tub, running on the ropes. The tub is attached by a third wire rope to a winding engine, the rate of winding being about 40 feet a second, or nearly 30 miles an hour.

The average weight of diamonds obtained per load (16 cubic feet) of blue rock varies greatly in the different mines; the ordinary limits may be put at $\frac{1}{8}$ and $2\frac{1}{8}$ carats. Those mines which have the largest number of stones do not generally produce the best quality, so that in the matter of profit there is a sort of compensating arrangement. The comparatively new Jagersfontein mine sends stones of finer quality than the better known Kimberley and De Beers mines. During 1889 the total output of diamonds from South Africa was four million carats, or about $\frac{1}{2}$ of a ton, the value of which may be estimated at rather more than £1 per carat, or more than four million pounds sterling. The finest diamonds at present in the market come from South Africa—notwithstanding the popular prejudice which assigns all diamonds of "the first water" (a term, by the way, which is not customary among diamond merchants, though dear to lady novelists) to the mines of Golconda or Brazil. Diamonds, exceeding the Koh-i-noor in size and equal in brilliancy, have been found in the South African mines, but such stones are no longer sought after. Their price, calculated to rise rather more rapidly than the square of the weight, is nominally very great, but no one will pay the price; and, strange as it may seem, such stones are now split up into two or three of the largest size that are ordinarily worn. The "crowned heads" are apparently now all furnished with crowns, and diamonds of a size which seems only suitable for regalia can no longer be disposed of.

To the mineralogist the chief interest of the South African mines lies in the fact that the blue rock, or "kimberlite," appears to be the original matrix of the diamond. Till of late years the diamond had only been found in alluvial deposits, its mode of occurrence giving no indication of its mode of formation. In kimberlite, however, it appears *in situ*, and the character of the minerals with which it is associated may perhaps afford some guidance as to the means to be adopted for the reproduction of diamond. The rock belongs to the class termed ultra-basic, having a low percentage of silica and a high specific gravity. The analogy of the rock to certain meteorites has been referred to in a previous article.

The following are the principal minerals of the rock:—

Blotite	Ilmenite
Bronzite	Olivine
Chrome diallage	Perowskite
Chrome iron ore	Pyrites
Garnet	Smaragdite
Graphite	

The olivine occurs in large quantity. This mineral, under the action of weathering, is decomposed, forming serpentine. In studying the occurrence of diamond-bearing sand and deposits in different parts of the world, the late Professor Carvel Lewis arrived at the conclusion that diamond-bearing deposits occur, as a rule, in water-courses which take their origin in mountainous tracts characterized by the presence of serpentine. Serpentine, or a rock which weathers to serpentine, was considered by Lewis to be the real matrix of the diamond. The position and mineralogical character of the kimberlite rock, filling in the neck of a volcanic vent, plainly show its igneous origin, and the fact that it has

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been protruded from below. It is not definitely known whether the diamonds were already formed in the rock before its eruption, or whether they had been produced by alteration of the materials contained in the rock displaced by the eruption. It is worthy of notice, however, that a black shale forms one of the surrounding rocks, and pieces of this shale have been found baked and otherwise altered in the "blue rock." The suggestion has been thrown out that the diamonds were formed by the alteration of the carbonaceous matter of the shale, under the influence of a moderately high temperature and great pressure. Such indications of origin are useful as affording suggestions to the experimentalist, to whom, however, in spite of previous failures, we must still look to tell us definitely how the diamond is formed.

Note.—I am indebted for most of the information on the methods of working in the mines to my friend Mr. A. R. Sawyer, A.R.S.M., formerly one of H. M. Inspectors of Mines, now resident in South Africa.

ON THE DISTANCE AND STRUCTURE OF THE MILKY WAY IN CYGNUS.

By A. C. Ranyard.

I AM indebted to Dr. Max Wolf, of Heidelberg, for the beautiful photographs of the Milky Way which illustrate this paper. The large plate, which represents the region about α Cygni, is enlarged from a photograph taken with an exposure of thirteen hours and five minutes, given on two successive days—viz.: 1891, September 9th, 9h. 0m. to 15h. 30m., and September 10th, 9h. 0m. to 15h. 35m.—with a camera of 134 millimètres (that is, about $5\frac{1}{4}$ inches) aperture, and a focal length of 770 millimètres (that is, about $30\frac{1}{3}$ inches). The camera, therefore, is of about the same focal length as the cameras used by Mr. Russell in Sydney, and Professor Barnard at the Lick Observatory, though the pencils of light falling on Dr. Max Wolf's plate were only about three-quarters as intense as those falling on the plates in the cameras of the Sydney and Lick Observatories; the aperture of Dr. Max Wolf's camera being 5·277 inches, as compared with a full six inches of aperture at the Lick and Sydney Observatories. During the long exposures Dr. Max Wolf was relieved by Messrs. Staus and Rosenplaenter in keeping the camera continuously directed to the region photographed. It will be seen that in all three plates the motion of the stars has been very satisfactorily followed.

The region shown in the large photograph is specially interesting for many reasons. It is a region rich in red stars, and also rich in the small class of stars which show bright lines in their spectra, and are known as Wolf-Rayet stars. It corresponds to the northern end of the great rift which divides the Milky Way into two branches throughout half of its course round the heavens, and it is a part of the Milky Way crossed by the zone of large stars referred to in the May and July numbers, as probably being at about the same distance from us as the Milky Way stream of nebulous light and small stars. Dr. Gould, speaking of this zone of large stars, says: * "Few celestial phenomena are more palpable than the existence of a stream or belt of bright stars traceable with tolerable distinctness through the entire circuit of the heavens, and forming a great circle as well defined as that of the Galaxy itself, which it crosses at an angle of about 20° in Crux and Cassiopeia. Traversing in the southern hemisphere Orion, Canis Major, Argo, the Centaur, Lupus and Scorpio, it pursues its way in the northern through Taurus, Perseus, Cassiopeia, Cepheus, Cygnus, and Lyra, its line being less obviously continued by the stars of Hercules and Ophiuchus."

It will be noticed that the two large stars in the picture (α and γ Cygni) are surrounded by a nebulosity very similar in appearance to other masses of nebulosity evidently associated with small stars. Thus the lower portion of the bright cloud to the right hand of the picture is composed of a milky nebulosity evidently associated with the stars which lie along its curving border, while the upper part of the same cloud-mass is more granular, and seems to consist of a multitude of small stars on a background of fainter nebulosity. The association of these large stars with nebulosity which certainly, in the case of γ Cygni, seems to extend into and form a part of a larger nebulous mass evidently associated with the small stars of the Milky Way, is another important link in the chain of evidence tending to show that the zone of large stars above referred to is at the same distance from us as the small stars of the Milky Way.

The star α Cygni is of the 1·5 magnitude according to the Harvard Photometric Catalogue, and we may safely assume that the smallest stars shown on the photograph which seem to be associated with the cloud-masses are not brighter than the 18th magnitude of the photometric scale. A difference of $16\frac{1}{2}$ magnitudes between two stars at the same distance from us, means that the brighter star must be giving about four million times as much light as the smaller one; that is, if the larger star had a photosphere as bright as the photosphere of our sun, and a diameter ten times as great, so that it gave a hundred times as much light as our sun, the small stars would, if they had photospheres as bright as the photosphere of our sun, have a diameter only a little greater than half the diameter of the earth.†

Thus, unless we suppose the diameter of α Cygni, and the other large stars associated with the Milky Way, to be enormously great, or unless we suppose them to be intensely bright compared with our sun, the smaller stars associated with them in the Milky Way must be very minute compared with our sun. The actual size of these suns is a matter of considerable interest to us, for if we knew the size and brightness of any of these stars, or if we could make any approximate estimate as to their light-giving power, we should have a means of determining the distance of the Milky Way. Thus, if we knew that α Cygni did not give a hundred times as much light as our sun, we should know that this region of the Milky Way could not be ten times as distant as α *Centauri*, our nearest neighbour amongst the stars, for our sun would probably appear less than a star of the 1·5 magnitude if it was removed to a distance from us equal to the distance of α *Centauri*.

Unless, therefore, we are prepared to believe that α Cygni, and all the other large stars associated with the Milky Way, are on altogether a different scale from our sun, as well as from α *Centauri* and the other stars whose magnitude or brightness we have been able roughly to estimate, we must assume that the Milky Way is not more than ten times as distant from us as α *Centauri*.

Figs. 1 and 2 have been made by a photographic process so as to show the chief stars in Cygni, recognizable in the two photographs on our second plate. With the

* *The American Journal of Science*, vol. viii., p. 333.

† If, on the other hand, the 18th magnitude stars associated with α Cygni are as large and as bright as our sun, α Cygni itself would need to have a diameter as great as the diameter of the orbit of Saturn, if its photosphere was only as bright as the photosphere of our sun.

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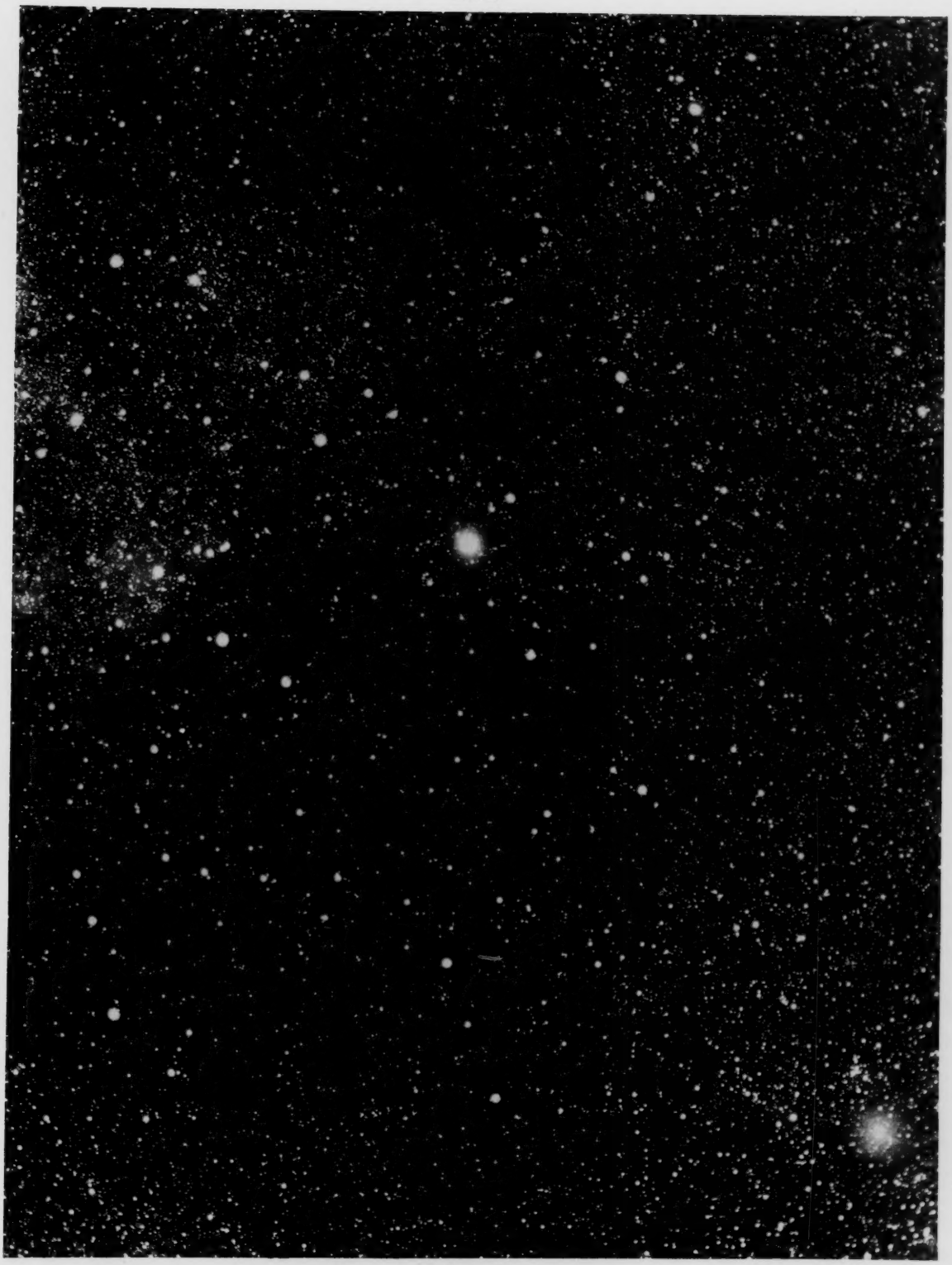
North.



The Region of the Milky Way about α Cygni.

Enlarged from a photograph taken by Dr. Max Wolf, of Heidelberg, with an exposure of 13h. 5m., on the 9th and 10th of September, 1891.

Direct Photo Eng. Co., Limited, 9, Barnsbury Park, N.

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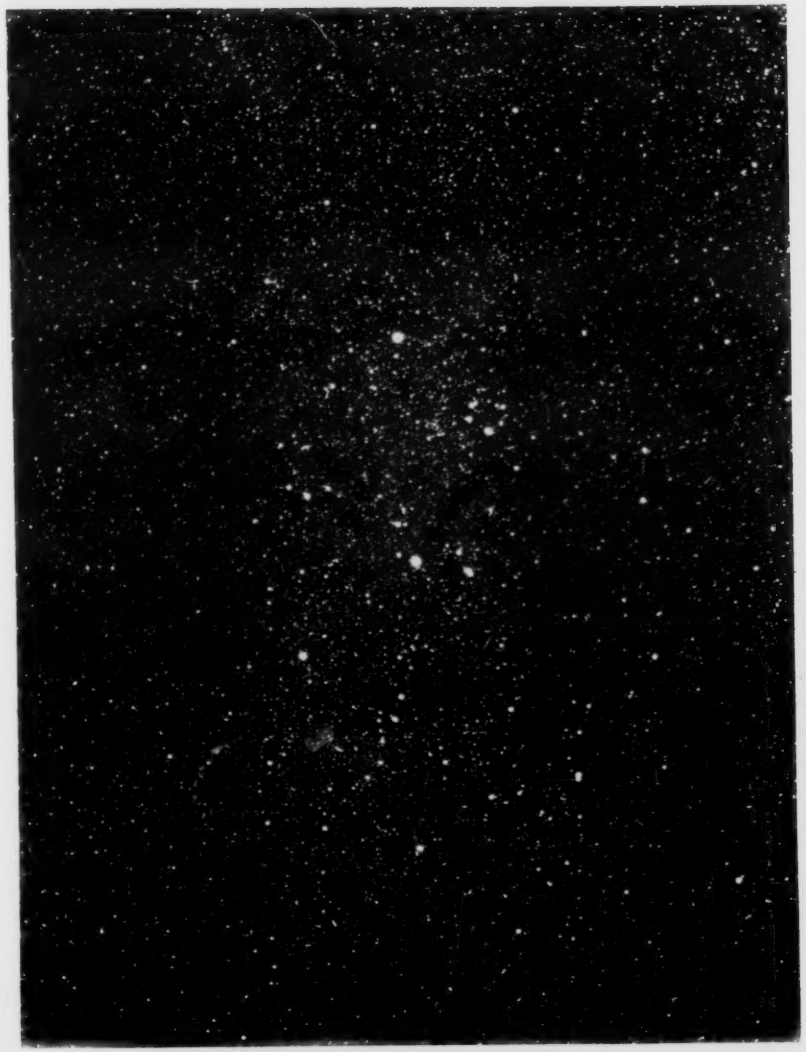
North.



The Region of the Milky Way about ε Cygni.

From a photograph taken by Dr. Max Wolf, of Heidelberg, with an exposure of two hours on the 13th July, 1891, and an exposure of three hours on the following day.

North.

The Region of the Milky Way about α Cygni.

From a photograph taken by Dr. Max Wolf, of Heidelberg, with an exposure of three hours, on the 1st June, 1891.

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exception of the letters and numbers upon them they are absolutely untouched. Fig. 2 very nearly corresponds with the region comprised in the large plate, and it will enable our readers to recognize on the heavens the chief patches of light and the brighter stars shown in the

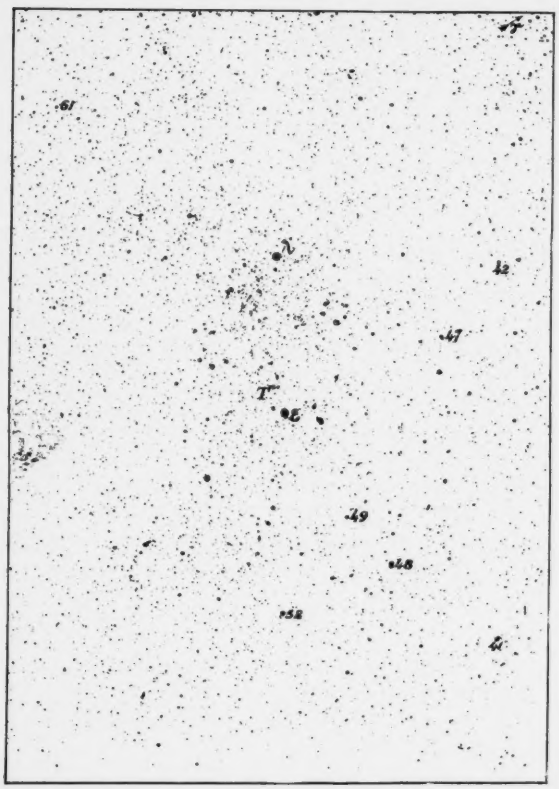

Fig. 1. Index map, made from Dr. Max Wolf's photograph, showing the principal stars about ϵ Cygni.

photographs. They are at present very conveniently situated for evening observation. The brighter stars in the curious circle of stars to the right hand, or preceding side of the line joining ε and λ Cygni, will at once be recognized with an opera glass.

On Dr. Max Wolf's photographs the region within and just around this little circle of stars is darker than the rest of the field, and it is connected with a dark channel which passes across the nebulous area close to ε Cygni. It seems to be part of a dark branching structure which springs from the darker region on the preceding side of ε Cygni.

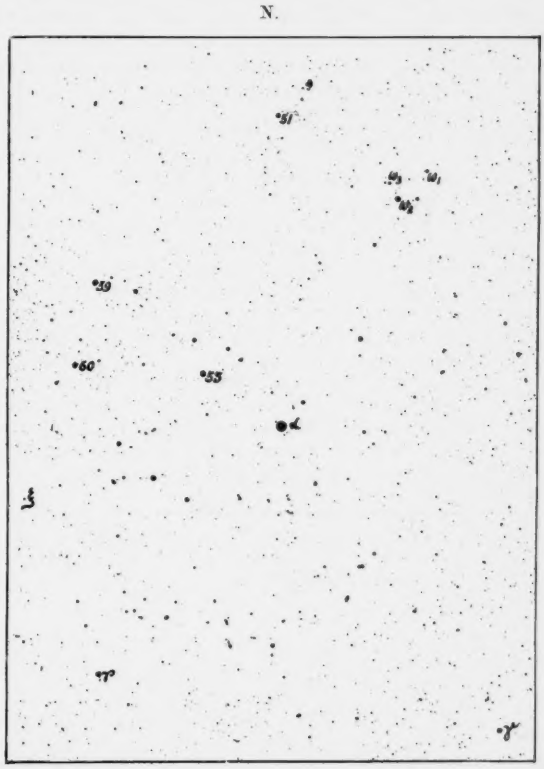

Fig. 2. Index map, made from Dr. Max Wolf's photograph, showing the principal stars about α Cygni.

A similar dark branching structure is well shown on our large plate a little to the north of α Cygni, and it is traceable running northward to near the top of the plate, and again branching. This is due to no photographic defect, for it is clearly visible on three different photographs of this region which have been sent me by

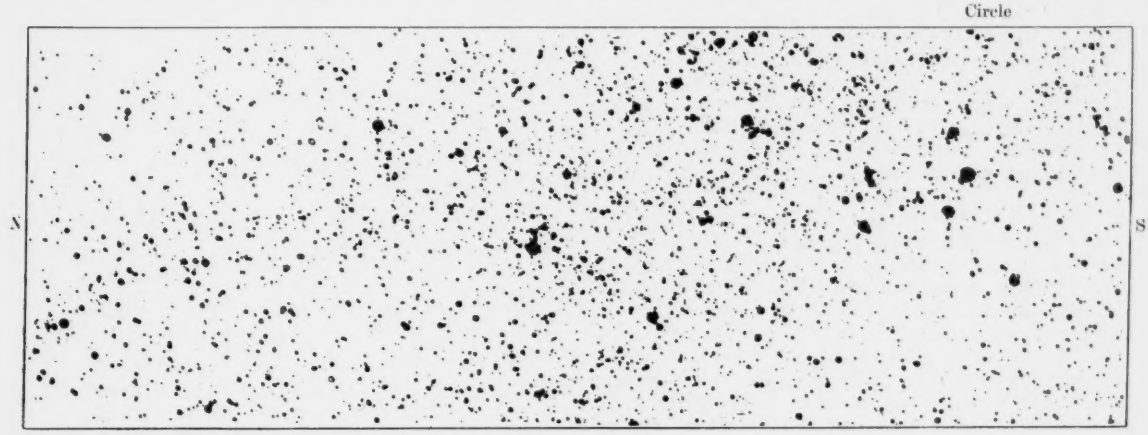

Fig. 3. Zinc photo-etching of a part of the ϵ Cygni photograph, on double the scale of the plate.

Dr. Max Wolf, and there are similar dark tree-like structures to be traced on Prof. Barnard's photograph of the Sagittarius region, a copy of which was published in the July number of Knowledge for 1890. Two of the most remarkable of the dark branching structures in the Sagittarius region spring from the dark area between the two clusters of stars near the bottom of the plate, and from this same dark area springs the bright tree-like form referred to on page 51 (Knowledge, March, 1891) as affording evidence of the projection of matter into a resisting medium.

It will be noticed that the dark channels and dark branching structures referred to are all bordered by lines of stars, which mark out their contour, just as the dark areas around η Argus are bordered by lines of stars. There are three striking dark patches, irregularly bordered by stars, near to the edge of the upper portion of the bright cloud-like mass to the right hand of the α Cygni picture. They are best shown in the large plate, though they are just visible in the small one. These dark patches remind one of the small dark hole bordered by stars in the Sagittarius region (see Knowledge, July, 1890, p. 175). The lowest of the dark patches on the Cygni plate has an elliptic-shaped group of small stars near its centre, surrounded by a dark elliptic channel. The patches seem to be connected together, and to form part of a dark structure, springing from the dark area to the south of α Cygni.

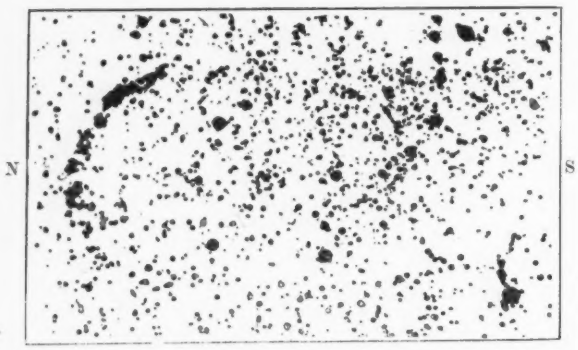

Fig. 4. Lightly etched plate, showing curving nebula and nebulous branches from 52 Cygni.

A remarkable series of slightly curved lines or strings of stars will be seen near to the top of the ε Cygni plate. The plate should be held sideways to see them best, as they run nearly vertically, that is, north and south upon the plate. I have made an enlarged photograph of this region, which I have had etched upon a zinc block (Fig. 3), but as many of the small stars are lost, the lines of stars are not as strikingly shown as upon the plate. It, however, shows a very curious little circle of stars, with radial streams, near to T Cygni. The radial lines of stars are evidently connected with the little circle of stars from which they radiate. The word "circle" is printed just above the small circle of stars on the block, but its striking character is best recognized on the plate.

That these curves and allineations of stars are not fanciful forms or chance arrangements, such as might be detected in the grouping of small objects thrown down at random (such as drops of rain falling on a paving stone), will be evident directly we consider the question from a probability point of view. Many of these star-streams contain twenty or thirty or more stars of about the same magnitude, following one another in a straight or curving line, at approximately equal intervals. If we assume that the chance is one to four that a point thrown down at random would appear to fall into line with two points already in position, the chance against ten such points falling into line with two already in position, so as to form a smooth curve, would be more than a million to one, and the chance against twenty such points falling into line would be more than a million of millions to one. This is much understating the improbability, for leaving out of consideration the chance that a series of adjacent stars having no physical connection should all be of nearly the same magnitude, and at about equal spaces from one another, the chance that the next adjacent star should fall into line with a series already in a straight or curving row must be less than $\frac{1}{12}$th, for the eye would certainly detect irregularities or deviations from the general trend of the curve amounting to 30°. We might, therefore, without any further evidence, take it as established that there must be an intimate connection between the stars of such a stream, and that they must have had a common origin, and form a system. But in the Pleiades cluster we have ocular evidence of a physical connection between the stars forming two such streams. The individual stars are connected together by a narrow nebulous band, "which threads them together." Prof. Pickering has also succeeded in photographing a faint nebulous band of light in the Orion region which passes through sixteen faint stars.* We have also some evidence of a similar connection on Dr. Max Wolf's

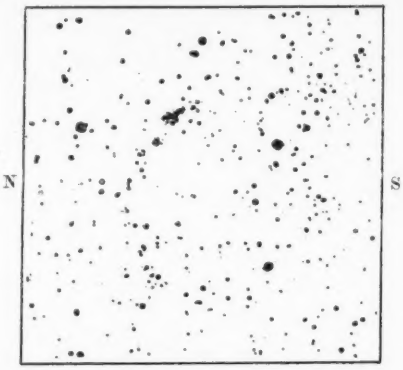

Fig. 5. Deeply etched block, showing stars involved in curving nebula.

ε Cygni photograph: I have had the small etchings, Figs. 4 and 5, made from a part of this plate, which shows a curving nebula involving stars. Fig. 4 has been lightly etched so as to show the nebulous band, and Fig. 5 has been more deeply etched so as to show the stars involved in the nebula and linked together by it. Fig. 4 also shows traces of two nebulous branches from the star 52 Cygni. It will be seen that small stars lie along these curving branches and appear to be connected together by them.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

THE OBSERVATION OF RED STARS.

To the Editor of Knowledge.

Dear Sir,—I fully agree with Mr. Franks that no demonstrative proof of colour instability in non-periodical stars is at present forthcoming. Nor is his scepticism

* See "Annals of Harvard College Observatory," vol. xxvii., p. 155.

without warrant from experience, since spurious instances of this kind of change might be counted by the dozen. What I would urge, accordingly, is not that any single alleged fact bearing on the point should be taken as established, but that a more determinate plan of investigation should be adopted than has hitherto been in use. Few will deny that a strong case for further enquiry has been made out. The evidence at hand is at any rate of sufficient weight for the purpose of directing special attention to certain objects, the rumoured colour-variations of which can be tested only by patient watching. Now, under this system, sundry processes of variation undoubtedly tend to become arrested, which seemed to show decidedly enough in the twilight of casual notice. Whether or not the changes imputed to red stars will fall into this category, remains to be seen. My personal conviction is that some of them will prove genuine, but it is founded, I admit, on a scanty basis of experience. Nevertheless, *r* Velorum made so striking an exception to the otherwise unfailing and emphatic redness of Gould's "red stars," so far as I was able to review them at the Cape, that I find it difficult to conceive of the change as apparent only. Properly speaking, however, all observations of this nature yet recorded ought to be regarded as merely indicative. A fresh start should be made with a view to ascertain—first, whether colour-variations really occur; secondly, what is their cause, if they do occur. Not that these two enquiries need be prosecuted separately or successively; the better plan would be to carry them on at the same time, and by the same means. In neither should the telescope be implicitly relied upon. The data afforded by it should have their meaning probed and deepened by the concurrent aid of the spectroscope. A useful adjunct, moreover, might be found in the photographic determination of relative magnitudes; for changes of tint would presumably be accompanied, and might even prove to be strictly measurable, through changes in the chemical intensity of the emitted light.

A. M. Clerke.

Ballysodare, Co. Sligo, Ireland,
18*th September*, 1891.

Dear Sir,—Looking over your interesting paper on the Pleiades in the May number of Knowledge, I was surprised to see that in your list of first magnitude stars (p. 91) you give Canopus only sixth in order of brilliancy! From my own observations in India I have no doubt that, with the exception of Sirius, Canopus is certainly the brightest star in the heavens. Indeed, on one or two occasions I found it very little, if at all, inferior to Sirius. Gould gives ("U.A.," p. 342) the order of brightness:—

Sirius	0·1	Arcturus	0 8
Canopus	0·4	α Lyræ	1·0
α Centauri ...	0·7	Rigel	1·0

and, setting aside α Centauri (with which I am not familiar), this is the order in which I should place them.

I am aware that there is a difference of opinion with reference to the relative brightness of Arcturus, Capella, and Vega, but to anyone who has seen Canopus there can, I think, be no doubt that it is brighter than any star in the northern hemisphere, I am aware that it has been suspected of variation—some observer in Chili, in 1861, thinking it brighter than Sirius!—but in its normal state it should, I think, certainly stand second on the list.

Yours very truly,
J. E. Gore.

I see in the "Cape Observations" Sir John Herschel gives the following sequence, observed March 28th, 1838:—

At Sea. Crossing the Line.

Sirius	0·10	η Argûs	—
Canopus... ...	0·22	Rigel	0·76
α Centauri ...	0·34	Procyon	0·85
Arcturus ...	0·45	α Orionis ...	1·00

[I have given the readers of Knowledge the benefit of Mr. Gore's letter, though I imagine that it was not written for publication.

Accurate photometric measures of the brighter stars in the southern heavens are much needed. The magnitudes given in the article referred to are from Prof. Pickering's "Photometric Catalogue for the Northern Sky" and from the "Uranometria Argentina" for the rest of the heavens. There must surely be some mistake about the estimates of Gould and Sir John Herschel of the brightness of *Sirius*. But if we adopt their order of magnitude, it makes no difference in the fact to which I wish to draw attention—that out of the twelve brightest stars in the heavens seven lie in the brilliant girdle of stars referred to, and three are intimately associated with it, being situated only just on the opposite border of the Milky Way.—A. C. Ranyard.]

ARE THE LUNAR RAYS DYKES, OR DUE TO FISSURES?

To the Editor of Knowledge.

Sir,—The paper on "Lunar and Terrestrial Volcanoes," in Knowledge, August 1st, pages 145-7, and your remarks thereon, are most interesting to students, and I trust you may allow me a small space for a few words about the rays.

With Mr. Hutchinson's conclusion, that the long white streamers radiating from Tycho and other craters cannot be due to "faults," most selenographers, who understand a little geology, will at once agree.

A fault is not only a fissure, but also a more or less vertical "slip," or dislocation, of strata, which leaves one side much higher than the other; hence, if the rays were due to faulting, we should (frequently) be able to detect this inequality by the shadows at sunrise and sunset.

As a matter of fact this feature is not seen in the rays, and, when we realize their width, this explanation of them may be safely set aside as untenable.

Mr. Hutchinson inclines to look on the rays as trap-dykes, or vast cracks into which some white molten rock has been extruded; but, as you have clearly pointed out, they are far too wide and indefinite along the edges to permit of this as a solution.

As Prebendary Webb so clearly points out, page 74 of his "Celestial Objects," "the chances against so general and exact a restoration of level, all along such multiplied and most irregular lines of exposure, would be incalculable."

If the rays were due to vast fissures, filled in with whiter material, the distortion (by displacement) of the detail would be quite extraordinary. Where a ray-dyke, ten miles wide, cut a cleft or ridge at an acute angle, the severed extremities could not possibly remain in line.

The entire region around Tycho, especially to the west, would in fact have been so revolutionized by the vast fissures and dykes, that the normal detail would have been *utterly obliterated* if the rays were due to this cause.

So that this also, as a solution for these singular white streamers, may safely be put aside as untenable.

With regard to the view that they may be due to snow deposit, along the margins of minute *fissures*, we are at once met by the difficulty of understanding how they come to be so long, so radially grouped, and so minute as to be nowhere visible. The difficulty, again, of conceiving such

a sustained uniformity in the discharge of vapour over such long lines seems to me insurmountable.

If the rays were occasionally interrupted by blanks, or if we could, even in a few cases, detect the fissure, this solution would appear more likely, inasmuch as the visible "clefts" are so obviously fissures in the crust, whence, here and there along their course, vapour has been given off which has been piled as snow cones, or little rings, called craterlets.

But there is no evidence of a fissure, as far as I am aware, in any of the rays, nor can we trace any evidence of a piling up, as in the strings of craterlets; the ray is simply a whitish streamer destitute of all structure, and which nowhere *deforms* the detail or modelling.

It is conceivable that among 1000 rays *one* might be due to a fairly straight (and continuous) minute fissure, whence aqueous vapour had been *so equably exhaled all along* as to give the appearance of a white streamer, as the snow was deposited on each side. That two such cases should occur would, however, be remarkable, and that *all* should present such a combination of features seems to me really incredible.

If we compare, in plan, the lines of fissure passing out from our great terrestial volcanoes (such as those figured on page 142 of Judd's "Volcanoes"), with the lunar ray systems, we at once see a radical difference. In our case the lines are not only strongly curved and branched, like rivers, but occasionally fork at right angles and terminate generally in *branchlets*, like a tree top, a feature which is quite foreign to the rays, as far as I am aware.

The rays, as a rule, appear to be solitary tracks, and this seems to me to preclude the idea of their being due to fissures, the more so as the visible "clefts" on the moon are often branched, forked, or crossed.

So that neither faults, trap-dykes, or fissures, exuding aqueous vapour, would seem to solve this perennial enigma.

Sibsagar, Assam, India. S. E. Peal.
August 28th, 1891.

[I do not think, with Mr. Peal, that the "clefts are so obviously fissures in the crust." Mr. Neison was inclined to regard them as the dry beds of lunar watercourses or rivers. At page 72 of his book on "The Moon," Mr. Neison says: "With regard to the true nature of these rills or clefts absolutely nothing is known, whilst they are too delicate objects to allow much, if any, of the details of their formation to be made out. It has been supposed they are cracks or fractures in the lunar surface, but their intersection and general conditions of existence seem quite inconsistent with such a supposition, more especially in their behaviour with reference to the various formations they pass through, round or over. In many points they bear some resemblance to the dried beds of lunar watercourses or rivers, but in many features do not seem in accord with such an origin, though perhaps it presents the most feasible explanation of their nature of all." We should not see such cracks in the lunar crust unless they were at least a quarter of a mile broad, and it does not seem to me probable that the precipitous sides of such cracks would stand (even under the action of lunar gravity) if the cracks were many miles in depth. The sides would fall together unless they were supported by pressure from the opposite precipice at very frequent intervals. One can conceive of such a deep crack filled with *débris*, or of a fault many hundred miles in length, if the opposite sides pressed against one another at sufficiently frequent intervals to give support. It is clear that the lunar rays have some connection with the volcanoes from which they radiate, and the theory which seems to me most probable is that they correspond to radiating cracks or faults which would not be seen from the earth.

Into such a fault or crack the lunar atmosphere would enter, however rare it may be at the surface, and it would be considerably compressed at great depths. We know that on the earth the atmosphere sinks into the interstices of the soil, and that on every fall in barometric pressure it rushes forth again, laden in many mines with gas. Everyone is familiar with the earthy smell of the air after a shower of rain, when the lowered pressure of the barometer allows the air which has been forced into the soil to rush back to the surface. No doubt the lunar atmosphere is similarly compressed into the soil, during the course of every lunar day, owing to the increased weight of the lunar atmosphere caused by the evaporation into it of aqueous vapour from the snows exposed to the direct heat of the sun. The air would be forced more freely into such deep fissures and cracks than into the ordinary soil, and it would return to the surface during the lunar night. We may feel sure that the expansion of the air on reaching the surface would cool it, as the air is here cooled by expansion as it blows up a mountain side. This is well known to be the cause of the great rain-fall on mountain tops, for the air, when cooled, will not carry as much aqueous vapour as at a warmer temperature. Similarly the lunar air would be cooled by expansion as it reached the surface, and it would deposit its moisture in the neighbourhood of the vent.

It does not seem to be altogether improbable that air should be pretty equally exhaled along the course of a long fault or fissure. The branching structure figured in Prof. Judd's book on volcanoes, referred to by Mr. Peal, does not represent cracks, but "intrusive masses of dolerite."—A. C. Ranyard.]

THE ABSENCE OF A LUNAR ATMOSPHERE.

To the Editor of Knowledge.

Dear Sir,—While composing a lecture on Astronomy, a few months ago, the following idea occurred to me as a possible explanation of the circumstance that our satellite is destitute of atmosphere.

It is well known that when comets approach the sun, large quantities of the gaseous portion of their contents are repelled by some powerful influence, probably the electrical action of the sun.

If, then, we assume that the earth has, at one time, passed through a sun-like stage, does it not seem probable that it would then exert a similar influence upon the atmosphere of the moon, the result of which would finally be that our satellite would be entirely denuded of her atmosphere?

If this explanation be the correct one, we may expect to find that all the other satellites in our system are likewise destitute of atmosphere, owing to this action on the part of their primaries.

The circumstance, accordingly, that no trace of an atmosphere has ever been discovered in connection with the satellites of Jupiter, furnishes confirmation of the above-mentioned theory.

Alexander C. Henderson.

Mount Pleasant Manse,
Newburgh, Fife, Scotland,
9th September, 1891.

[We have no evidence that gaseous matter is repelled from the heads of comets and driven into space. The polarized condition of the light derived from the tails of comets shows that the light of the tail is principally

scattered by fine particles of dust, which are most probably driven away from the sun (not by electrical action), but by evaporation from their heated sun-lit sides. Every molecule evaporated from a particle towards the sun must give the remnant of the particle a kick backwards (see Knowledge for November 16th, 1883), which would tend to drive the unevaporated remnant away from the sun. It seems very improbable that gaseous matter is driven away from the sun, or the gaseous part of the corona and prominences would be driven away, and the sun would be continually diminishing in bulk.

We do not need to assume altogether different conditions to account for the disappearance of a lunar atmosphere. Our own ocean of atmosphere is continually being drained by the absorption of gas which is stored up in solid form, while there are other sources from which the atmosphere is continually being recruited. If, owing to some change, such as a change of temperature, the supply of gas to the atmosphere were to fall below the quantity which is continually being taken up and stored in solid form, the amount of our ocean of atmosphere would be diminished, and it might ultimately be drawn so low as to fall below the amount of the lunar atmosphere by the action of chemical changes such as are at present going on.—A. C. Ranyard.]

ON SOME PECULIARITIES OF THE VARIABLE STARS.

By J. E. Gore, F.R.A.S.

THE long period Variable Stars have periods ranging from 100 to over 700 days, and with fluctuations of light from about one magnitude to over eight magnitudes. Dividing these into groups, I find that the maximum number is found among those with periods of 275 to 375 days. Chandler finds that the longer the period the redder the tint. According to Chandler's estimates of their colours, the reddest of all are —in order—R Leporis (period 436 days), V Cygni (461 days), S Cephei (484 days), R Sculptoris (207 days), and V Hydræ (575 days). Dunér, however, makes the reddest variables V Hydræ, S Aurigæ, and V Cygni.

The Variable Stars of short period include 19 stars with periods of less than 30 days. Of these I find that four have periods of under five days, eight have periods of under eight days, three have periods of less than 11 days, and three under 18 days. The maximum number is, therefore, under eight days. The variation of light is usually small. In but few cases does it much exceed one magnitude, and in several it is less. In some, as in β Lyræ, ζ Geminorum, and η Aquilæ, all the changes may be observed with the naked eye alone, while in others an opera glass is necessary to follow their fluctuations.

The great majority of these short period variables are found in a zone which nearly follows the course of the Milky Way. Another curious peculiarity connected with their distribution is that most of them lie—like the Temporary Stars—in the *following* semicircle, that is, between 12 h. and 24 h. of Right Ascension. The most remarkable exception to this rule seems to be ζ Geminorum, which has a period of about 10 days $3\frac{3}{4}$ hours. All the Variable Stars of this class with shorter periods than ζ Geminorum conform to this rule, except S (15) Monocerotis, of which the *regular* variability seems very doubtful. It is not easy to conjecture the cause of this peculiarity of position, for the Variable Stars of other classes are found scattered indifferently over all parts of the celestial vault.

Of the Algol type variables the brightest are Algol, λ Tauri, and δ Libræ. The others are much fainter, only two being visible to the naked eye when at their normal brightness. Chandler finds that "the shorter the period of the star the higher the ratio which the time of oscillation bears to the entire period." Thus, in U Ophiuchi, with a period of about 20 hours, the light changes occupy five hours, or about one-fourth of the period, while in δ Cancri, of which the period is about $227\frac{1}{2}$ hours, the fluctuations of light occupy $21\frac{1}{2}$ hours, or about one-tenth of the period. All the Algol variables are white, or only slightly tinted, and it would therefore seem to be hopeless to look for variables of this class among the highly-coloured stars. In all cases in which the stars have been examined with the spectroscope the spectrum is found to be of the first or Sirian type, another peculiarity worthy of notice. The same remark applies to the stars which have been found by the spectroscope to be close binaries, such as ζ Ursæ Majoris, β Aurigæ, and Spica. These have spectra of the first type, and may be considered as Algol variables in which the plane of the orbit does not pass through the earth.

If we assume that the apparent variation of the Algol variables is due to the transit of a dark or nearly dark satellite, we seem logically compelled to conclude that these stars are not really variable at all in the true meaning of the word. Their light is merely obscured at minimum in the same way that the Sun's light is reduced during a partial Solar eclipse. It is simply a case of occultation of one star by another, and probably these so-called variables might more correctly be classed among the binary stars. If, like the Temporary Stars, we reject the Algol variables, we have then only three classes of true Variable Stars, viz.:—(1) stars with regular periods of considerable length, (2) irregular variables, and (3) variables of short period.

With reference to the general distribution of the Variable Stars, I plotted some years since all the known variables on one chart for each hemisphere, and I do not find any *very* marked tendency to aggregation in any particular region of the sky. A marked *paucity* of Variable Stars is, however, noticeable in the northern hemisphere in the constellations of the Lynx, Coma Berenices and Canis Venatici, and in the southern constellations, Canis Major, Columba, Pictor, Eridanus, Fornax, Horologium, Grus, Microscopium, Indus, Toucan, Hydrus and Octans. I notice, however, a tendency to congregate in small subordinate groups. The most remarkable examples of this clustering tendency are as follows:—In and near Corona Borealis, where, in a comparatively small region there are five Variable Stars; near Cassiopeia's Chair, five; in Cancer four, comparatively close together; a small region near η Argûs, containing six; and a limited area near the head of Scorpio, which contains no less than 15 small variables. I find that if the whole sky were as rich in variables as this last-named region there would be about 3000 Variable Stars. The number hitherto discovered has not yet reached 300.

A remarkable peculiarity about the Variable and Temporary Stars is, that few of them show any appreciable parallax. For α Cassiopeiæ and α Herculis a parallax of less than a tenth of a second of arc has been found, but for α Orionis Dr. Elkin finds a negative parallax. These are irregular variables. Observations of Nova Cygni (1876) by Sir Robert Ball, failed to show a measurable parallax. For the new star of 1885 in the Andromeda Nebula, Franz also found a negative parallax. A negative parallax implies either that the parallax is too small to be measured, or else that the faint comparison stars are actually nearer to the earth than their brilliant neighbour. As far as I

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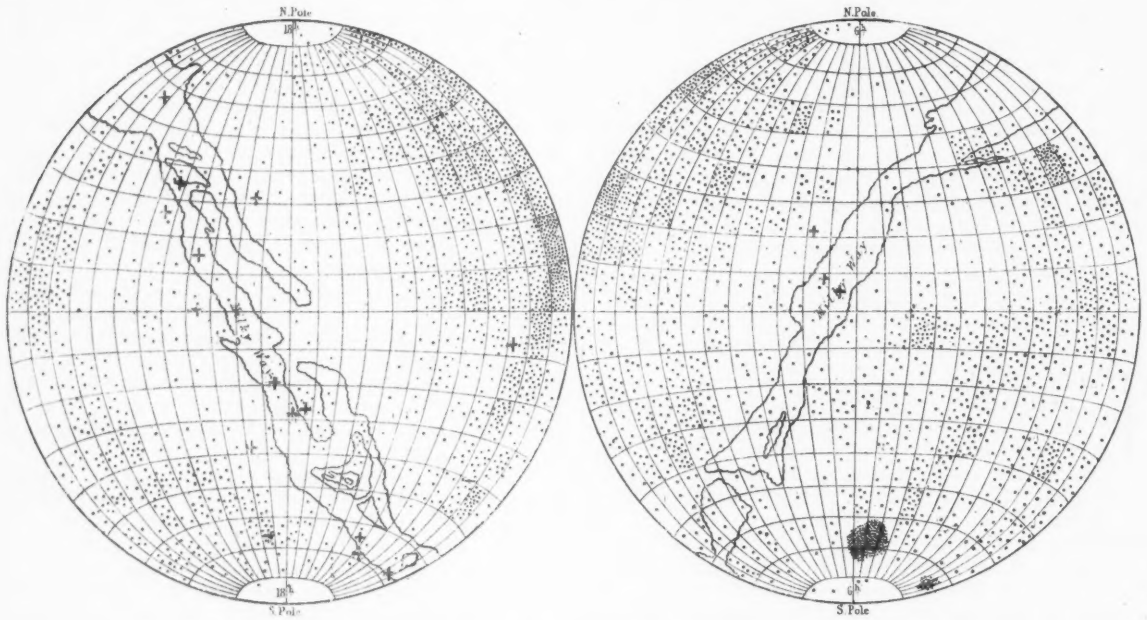
know, a measurable parallax has not yet been found for any variable star having a *regular* period. Another fact which may perhaps suggest (although it does not *prove*) great distance, is that few of the long period variables rise, even at maximum, above the range of naked eye visibility. As in the case of most rules, however, there are exceptions to this one ; Mira Ceti, R. Hydræ, and χ Cygni being the most notable examples.

The evidence in favour of great distance is further strengthened by the fact that none of the Variable Stars have any considerable proper motion. The list of proper motions greater than one second of arc per annum, given in Miss Clerke's "System of the Stars," does not contain a single known Variable Star. We seem, therefore, to have evidence that the Variable Stars lie at a vast distance from the earth. How is this peculiarity to be accounted for? The only plausible explanation I can see is that the Sun and Solar system do not lie in a region of Variable Stars. The periodical increase and decrease of sun-spots may possibly denote some *small* fluctuation of light in our Sun, but seen from the nearest fixed star, this variation of light, if it has any real existence, would be quite imperceptible, and the Solar light would probably seem to be invariable. Our nearest neighbours in the Sidereal System, α Centauri, 61 Cygni, Lalandi 21,185, Sirius, &c., appear constant in their light, a proof that in a large region of space surrounding the Sun there is not a single Variable Star.



Map on the Isographic projection, showing the place of twenty Short Period Variable Stars with reference to the Milky Way and Nebulæ. The Short Period Variables are represented by crosses and the Nebulæ by dots.

Remarks by A. C. Ranyard.

In order to exhibit to the eye the grouping of the short period variables mentioned by Mr. Gore, I have plotted down the places of the 20 variables of short period referred to on one of Mr. Proctor's pairs of maps, showing the distribution of nebulæ with respect to the Milky Way. It will be seen that 19 out of 20 of these short period variables lie on or near to the region thickly strewn with stars and nebulous matter which we know as the Milky Way. This same region is also rich in red stars and in stars exhibiting bright lines in their spectra, as well as in large and irregular nebulæ, and in star clusters—while the smaller nebulæ seem to avoid it, and to cluster in the poles of the Milky Way. W Virginis, the only one of the short period variables which falls at a considerable distance from the Milky Way, has a comparatively long period of 17·27 days, and its spectrum seems to differ from the spectra of other short period variables.

The distribution of short period variables with respect to the Milky Way was pointed out some years ago by Prof. E. C. Pickering. Miss A. M. Clerke, in her "System of the Stars," p. 145, remarks that within the zone of the Milky Way these short period variables display "an evident disposition towards clustering where the Milky Way divides in Cygnus; the variables follow its southern branch, and they are thickly sown over the whole region from Lyra to Sagittarius." Indications indeed abound, that the conditions of variability and even of particular kinds of variability are localized in space. Thus in Sagittarius no less than four stars fluctuate in periods of six to seven days.

The absence of any appreciable parallax in variable stars need not necessarily be due to their great distance. All modern determinations of parallax are based on measures of the distance of the star whose parallax is sought from small stars in its neighbourhood. If variable stars occur in groups or are situated in clusters of small stars, we should expect to find no relative parallax compared with small stars situated at about the same distance from us as the principal star. We have so few stars showing undoubted parallax that it would be unsafe to base any important general conclusion on the fact that no star of the variable class has yet been discovered showing such parallax ; but it is more remarkable that no variable star shows any considerable proper motion. I am indebted to Mr. Gore for the following interesting table.

VARIABLE STARS OF SHORT PERIOD.

Star.	R.A., 1890·0.	Decl., 1890·0.	Variation.		Mean Period, Days.	Colour.	Spectrum.	Remarks.
			Max.	Min.				
	H. M. S.	DEG. MIN.	MAG.	MAG.				
T Monocerotis	6 19 20	+ 7 8·7	5·8 — 6·4	7·4 — 8·2	27·00	Yellow	IIa. (?)	
S (15) Monocerotis ...	6 34 55	+ 9 59·7	4·9	5·4	3d. 10h. 38m. (?)	White	Ia.	Period doubtful
ζ Geminorum	6 57 36	+ 20 43·9	3·7	4·5	10d. 3h. 41·5m.	Yellow	—	
R Muscæ	12 35 23	− 68 48·2	6·6	7·4	0d. 21h. 20m.	White	—	
W Virginis...	13 20 21	− 2 48·5	8·7 — 9·2	9·8 — 10·4	17·27263	Reddish	III. (?)	
*T Trian Australis ...	14 59 29	− 68 17·7	7·0	7·4	1+	White	—	Variation doubtful
R Trian Australis ...	15 9 56	− 66 5·5	6·6	8·0	3·4	White	—	
X (3) Sagittarii	17 40 38	− 27 47·2	4	6	7·01185	Yellowish	—	
W (γ') Sagittarii	17 58 0	− 29 35·1	5	6·5	7.59445	Yellowish	—	
Y Sagittarii	18 14 55	− 18 54·5	5·8	6·6	5.7690	White	—	
U Sagittarii	18 25 24	− 19 12·3	7·0	8·3	6·74493	Orange	—	
K Pavonis	18 45 37	− 67 22·3	4·0	5·5	9·097	—	—	
β Lyræ	18 46 1	+ 33 14·1	3·4	4·5	12d. 21h. 46·97m.	Yellowish	Bright Lines	
S Coronæ Australis ...	18 53 43	− 37 6·5	9·5	13·0	6·2 (?)	—	—	
U Aquilæ	19 23 26	− 7 16·2	6·3	7·3	7·033	—	—	
η Aquilæ	19 46 52	+ 0 43·4	3·5	4·7	7d. 4h. 14·0m.	Yellow	IIa.	
S (10) Sagittæ	19 51 0	+ 16 21	5·6	6·4	8d. 9h. 11·0m.	White	—	
X Cygni	20 39 5	+ 35 11·4	6·4	7·2 — 7·7	16d. 9h. 36.9m.	White	—	
T Vulpiculæ	20 46 34	+ 27 48·9	5·5	6·5	4d. 10h. 29·0m.	White	—	
δ Cephei	22 25 5	+ 57 51·1	3·7	4·9	5h. 8h. 47·66m.	Yellow	—	

* Note.—T. Trian Australis is not included in the 19 Variables mentioned in Mr. Gore's paper, as its variability has not yet been confirmed.

THE PERFUMES OF ANTIQUITY.

By J. Ch. Sawer, F.L.S.

PROBABLY the word "perfume" is derived from *per fumum*, "by the aid of smoke," and originated in that most ancient custom of burning resinous substances and aromatic woods in religious ceremonies, thus creating an odoriferous smoke, which was doubtless of advantage in the early form of worship as a disinfectant or deodorizer in counteracting the offensive odours of the burning flesh of the offerings. In other countries where animals were not slaughtered and burned, the incense no doubt acted on the mystical imagination of the worshipper, its overpowering vapours throwing him into a religious ecstasy conducive to the belief in the acceptance of his prayer as he observed the gradual ascent of the smoke from the altar and its dispersion in space.

The incense ordered for the service of the Tabernacle, to be burned in a censer and on the Altar, consisted of Stacte, Onycha, Galbanum and Frankincense in equal parts.

Stacte (σταχτή), which is the Greek translation of the Hebrew word נטף (nataph), signifies a liquid exudation, or something fluid. Pliny describes it as the natural exudation of the myrrh-tree, flowing without the tree being punctured, and more esteemed than myrrh itself. Theophrastus also mentions two sorts of myrrh, one liquid and one solid.

Onycha is the Hebrew *Schecheleth*, "odoriferous shell." It is the *operculum* of a species of *Strombus*, formerly well known in Europe under the name of *Blatta Byzantina*, found in the Mediterranean and in the Red Sea, from which latter the Israelites no doubt procured it. It is occasionally to be seen at the Custom House of Bombay, where it is imported to burn with incense in the temples, not so much on account of any pleasing odour of its own as to bring out the odour of other perfumes. It is a white transparent shell, resembling in shape the human finger-nail; hence its Greek name ὄνυξ, *onyx*, a finger-nail. It is generally believed that the fish inhabiting this shell acquires its peculiar odour by feeding on a species of Indian Nard.

Galbanum חֶלְבְּנָה (*Chelbenah*). The word signifies something unctuous, and evidently applies to a balsam. According to some authorities it is a fine sort of galbanum found on Mount Amomus in Syria, differing entirely from the ordinary galbanum now used in medicine, of which the odour is anything but sweet. But the fashions of this world change, and if we, in our day, find no sweetness in galbanum, saffron, and spikenard, it is no reason why the ancients did not, and no reason why Orientals should not, even now. At the present day the Persians call asa-fœtida "the food of the gods," the Russians delight in caviare, and the Esquimaux in train oil.

As an example of the preservation of ancient Jewish customs, galbanum still forms one of the ingredients of the incense now used in the Irvingite chapels in London.

Frankincense.—This is largely imported into London under the name of Gum Olibanum, and is used principally in the manufacture of incense for the Roman Catholic and Greek Churches. The Greek word λίβανος, the Latin *Olibanum*, the Arabic *Lubàn*, and analogous words in other languages are all derived from the Hebrew *Lebonah*, which signifies *milk*, in allusion to the sap of the trees, which, before becoming dry by exposure to the air, has the appearance of milk. This drug was imported into China from Arabia as far back as the tenth century, and is still imported to an enormous extent at Shanghai to this day, under the name of *Ju-siang*, meaning *perfume of milk*, being always in allusion to the meaning of its Hebrew name *Lebonah*.

Olibanum is derived from several species of Boswellia, indigenous to the hot arid regions of Eastern Africa, the southern coast of Arabia, and some parts of India.†

The trees vary greatly in height, averaging about twenty feet; their form is very graceful, and when springing from a massive rock on the brink of a precipice their appearance is very picturesque.

The harvest of this drug in Southern Arabia is thus described by Carter:—"During the months of May and

† An enumeration and description of these trees is given by Birdwood in the "Transactions of the Linnæan Society," xxvii., p. 3, and in the "Journal of the Bombay Branch of the Royal Asiatic Society," ii., p. 380.

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December longitudinal incisions are made in the bark; the cuticle and adjacent parts then become shining and distended. When the gum first begins to run it is white as milk, and according to its degree of fluidity runs down to the ground or concretes on the tree near to the incision. It is then collected by the families owning the land." According to Capt. Miles ("Jnl. R. Geograph. Soc.," xlii., 65), the gum is not collected by the inhabitants of the country, but by the Somalis, who come over in large numbers from the opposite coast and pay a tribute to the Arabs for it, gathering it themselves. He considers the Arabian Lubàn inferior to the African.

As found in commerce, olibanum varies greatly in quality and appearance. It occurs in the form of rounded fragments of a pale yellow and sometimes reddish colour, also in pale yellow or nearly colourless distinctly pear-shaped tears, sometimes stalactiform and slightly agglutinated. It is always of a mealy surface covered with a fine white dust, and even where this is wiped off the tears appear translucent and milky. The fracture is splintery; the odour faintly balsamic; the taste bitter.

These four ingredients would doubtless burn readily if cast on the fire of the altar, and probably burn with a flame, but to develop a smoke the ingredients should burn slowly, or smoulder. If burned in a censer an incense of this composition would very likely go out by melting into a solid lump. In modern incense the difficulty is overcome by adding pulverized charcoal and nitrate of potash, but Moses does not specify any other ingredient.

In the description of the composition of the holy incense given in the Talmud (Book "Cheritoth"), we find the words "borith Carshina," which are usually translated "soap of Carshina," but soap would form a very bad ingredient for incense. Soap was unknown to the Jews, and the word "borith" (בּוֹרִית) is more likely to refer to a natural alkaline production of Judæa, somewhat similar to the Egyptian "natron" or "nitrum," or to the nitrate deposits of Chili. Such an addition to the ingredients would supply the oxygen necessary for combustion.

From Ex. xxx. 22-38 we find that the *holy anointing oil* for the service of the Tabernacle was composed of myrrh, sweet cinnamon, sweet calamus, cassia, and olive oil. The word *myrrh* is derived from a Hebrew word, signifying in French *amer*, and in English *bitter*. It is also said to be derived from the Arabic word *mur*. The Greek equivalent is σμύρνα. The ancient Egyptian word Bola or Bal, and the Sanskrit Vola, are yet preserved in the Persian and Indian names Bol, Bola, and Heera-Bol, well-known names of myrrh. Myrrh is a gum-resinous exudation from the stem of the *Balsamodendron myrrha*, collected in Arabia Felix and Abyssinia, a spiny shrub of which there are at least three distinct species. Good commercial myrrh is in irregular-shaped masses of a reddish-brown colour and slightly translucent. It has a dull irregular fracture and an aromatic and characteristic odour. The Bissa-Bôl, which is an inferior quality and much adulterated, was formerly called East India myrrh and is of African origin, but the plant furnishing it is unknown, although it is said by the natives to much resemble the tree yielding the Heera-Bôl or true myrrh. The variety from which the ancients principally drew their supplies was probably that of Southern Arabia; this has the same odour as ordinary myrrh, and is not distinguished from it in English commerce by any special denomination.

The "sweet cinnamon," called "kinnamon" in the Old Testament and κινάμωμον in the New (Rev. xviii. 13), is Ceylon cinnamon.

The "sweet calamus" (Keneh bosem); the "sweet cane" (Keneh hotteb, Jer. vi. 20), and "calamus" (Kaneh, Song of Sol. iv. 14, and Ezek. xxvii. 19) is, according to some authorities the *Andropogon Calamus aromaticus* of Royle, which is synonymous with the Andropogon Schænanthus of Linnæus, and known in India as Roosa-grass and in London as "Ginger-grass." This grass grows wild in Central India, in the North-West Provinces, and is abundant everywhere in the Deccan. It has recently been found on the Hurnai Railway route in Baluchistan (Lace in "Jnl. Lin. Soc.," xxviii., 296, Aug., 1891). At the present day this grass is largely used for the distillation of its oil, which is employed in the adulteration of otto of rose.

It is, however, very probable that the "sweet calamus" was the *Andropogon laniger* (Desfontaines). This plant has a wide distribution, extending from North Africa, through Arabia and North India to Thibet. It is the σχοῖνος ἀρωματικὸς of Dioscorides and the Herba Schænanthus and Juncus odoratus of Latin writers on Materia Medica. The Arabic name is Izkhir, which signifies stored-up forage. It has also been called Fœnum Camelorum, from its use in dry desert tracts as a forage for camels. When cattle eat much of this grass, the milk becomes scented. Lemery, commenting on Pomet ("Hist. des Drogues"), says that "this is a kind of fragrant rush or grass growing plentifully in Arabia Felix, at the foot of Mount Libanus. The stalk is about a foot high, divided into several hard stems, of the size, figure and colour of barley straw, being much smaller towards the top. The leaves are about half a foot long, narrow, rough, pointed, of a pale green colour. The flowers growing on the top are arranged in double order; they are small, hairy, and of a carnation colour . . . . all the plant, and particularly the flower, is of a strong smell and bitter taste."

The other odoriferous ingredient in the holy anointing oil, *Kiddah* (Exodus xxx. 24), is translated *cassia*. In Psalm xlv. 8 it is called *Ketzioh*, and here, undoubtedly, *Cassia lignea* is meant. This is the bark of the *Cinnamomum Cassia*, a forest tree of China. Another variety called Malabar cassia, is exported from Bombay; this is thicker and coarser than that from China. These barks resemble cinnamon in many of their qualities; the smell and taste are nearly the same, but less sweet and more pungent, but the substance is thicker and the appearance coarser and darker than cinnamon. All these barks contain a very aromatic volatile oil and a resin.

In the holy anointing oil the proportions of these aromatics, as indicated by Moses (Ex. xxx. 22-38), are 500 *shekels* of myrrh, 250 of sweet cinnamon, 250 of sweet calamus, and 500 of cassia; to these were to be added 1 *hin* of olive oil. Although we here have the formula of this compound, the mode of making it is not described, and it is difficult to conceive how 1 *hin* of oil, which is about $9\frac{3}{4}$ pints, could hold in solution so much solid matter, the total weight of which, 1500 shekels, is equal to about 47 lbs. Such an amalgam would only produce a very thick paste, and the oil was evidently intended to be liquid, as it was not only ordered to be used for anointing the altars and utensils of the Tabernacle, but was commanded to be used for consecrating the High Priest, by pouring it on to his head in such abundance as to run down his beard and impregnate the skirts of his garments (Psalm cxxxiii. 2). Probably the odoriferous properties were in some way separated from the ligneous matter before mixing with the olive oil.

Several other aromatic substances used in the early ages have been the theme of modern investigation and dispute. The substances were sometimes made up in the form of ointments, which were lavishly used by the rich, not only in their toilet but also as a mark of distinction

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bestowed on guests. Aromatics were likewise burned during their entertainments, and perfumes in a dry form were used to impart a sweet odour to their garments (perfumes which were probably necessary, as they did not eat with forks, and soap was yet undiscovered). Odoriferous substances were used for preserving the bodies of the dead; myrrh and aloes wood were in this mixture, which was very likely an unguent. The Spikenard ointment is said to have been of many ingredients; the word *nard* is derived from the Tamul word *nar*, which is used in India to designate many odoriferous substances, such as *nártum pillu*, Indian verveine; *nárum panei*, jasmine; *nárta manum*, wild orange, &c.

The "Nardinum" which was so very fashionable in Rome, both as an oil and as a pommade, was made from the blossoms of the Indian and Arabian nard-grass (according to Briker's opinion and researches). This would seem to refer to the *Andropogon laniger* above mentioned, and not to *Nardostachys Jatamansi*, as generally believed. The flowers of this latter are white and odourless, the rank perfume being only developed in the root.

As is the case generally in hot climates, oil was used by the Jews for anointing the body after the bath, and giving to the skin and hair a smooth and comely appearance before an entertainment (Ruth iii. 3, Prov. xxvii. 9, 16, Cant. i. 3, iv. 10). Strabo says the inhabitants of Mesopotamia use oil of sesame, also castor oil. At Egyptian entertainments it was usual for a slave to anoint the head of each guest as he took his place, castor oil being sometimes used; Egyptian paintings represent this custom. The Greek and Roman usage will be found mentioned frequently by Homer, Horace and Pliny. Athenæus speaks of the extravagance of Antiochus Epiphanes in the matter of ointments for guests (Wilkinson, "Ancient Egypt," 78).

Creech, in his annotations on Lucretius (Lib. IV. 1123), says: "Moreover they arrived at length to an excess of curiosity in regard to their ointments that was indeed wonderful; for Athenæus (Lib. XV. cap. II.) reports that 'they grew so nice as to require several sorts of ointments for one single unction, viz., Egyptian for the feet and thighs, Phœnician for the cheeks and breasts, Sisymbrian for the arms, Amaratine for the eye-brows and hair, and Serpylline for the neck and knees.'" But above all the rest, we may observe that the ancients made use of one sort of oil or ointment of great value and singular excellency; it was called *Oleum Susinum*, and made of lilies which in the Phrygian tongue were called σύσα, but chiefly of that sort of lily which the Greeks call χείνον, and to which it is believed allusion is made in Canticles v. 13, where the Church says of Christ, "His lips are like lilies."

Pliny describes the lily that is called χείνον to be of a ruddy colour (Nat. Hist., lib. XXI. cap. 5). Elsewhere, Pliny (Hist. Nat. XIII. 2) says, "*Oleum Susinum* was made of oil of Ben" (or Behen, a colourless, tasteless and inodorous oil expressed from the seeds of *Moringa pterosperma*, now naturalized in the West Indies—an oil which never becomes rancid and does not corrode steel, for which reason it is used in modern days by watchmakers as a lubricant), "roses, honey, saffron, cinnamon and myrrh." The amount of perfume used in the palmy days of Rome was enormous; the wealthy patricians were most prodigal in this respect. The perfumers were called *Unguentarii*, as they principally compounded unguents, and must have done an immense business. In Rome they congregated in a quarter called the "*Vicus Thuraricus*." The most celebrated perfumer in the time of Martial was a certain individual named Cosmus, whom Martial frequently mentions.

At Capua there were such a number of perfumers, that the principal street of the city, named Séplasia, was almost entirely occupied by them. For the most part, these tradesmen were Greeks, and, as at Athens, their shops (taberna) were the rendezvous of the rich idlers of those days. The perfumed oils and ointments were made in great variety. The basis of the oils was generally the oil of Ben above-mentioned, and that of the unguents was a bleached and partly purified tallow. They were used not only for the hair, but to anoint all parts of the body, especially after the bath, which was quite a complicated process. It was also customary at banquets to honour the guests by pouring costly perfumed oils over their feet. Some of these were simple oils, such as *Rhodium*, made from roses; *Melinum*, made from quinces; *Metopium*, from bitter almonds; *Narcissimum*, from the narcissus. Perhaps the most fashionable oil after the *Oleum Susinum* above-mentioned was that called *Crocinum*, made from saffron (*Crocus*), which communicated both a fine colour and odour to the person; Heliogabalus never bathed without it. Butter is noticed by Pliny as used by the negroes and lower classes of Arabs for anointing their bodies. The natives of India prefer strong perfumes for this purpose, and use oil of santal and oil of patchouli. Savages also grease their bodies, but probably with the idea of being enabled to escape more easily from the grip of an enemy.

In the words of a classical writer on the manners and customs of the Romans, "The bath was a most important event in every-day life . . . Bodily health and cleanliness, although its original object, had long ceased being the only one; for the baths, decorated with prodigal magnificence and supplied with all the comforts and conveniences that a voluptuary could desire, had become places of amusement, whither people repaired for pastime and enjoyment."

Comparing the ruins of ancient baths with each other, and with the accounts of Vitruvius and Pliny, we find the essential parts of a Roman bath to be:—I. The *Spoliatorium*, a place where the clothes were left and consigned to *caprarii*, which were probably pegs, so called from their likeness to horns. II. The *Frigidarium* or cold bath room. III. The *Tepidarium* or tepid bath room. IV. The *Caldarium* or hot bath room, which was probably connected with the *Unctorium* or anointing room. The *Sudation* or sweating room was connected with the *Caldarium*. Those who desired to use the bath through all degrees of temperature, sought first to give their bodies the preparation which was considered necessary, by some sort of light gymnastics, ball-play and the like. The baths were always provided with rooms suitable for this purpose. Persons would then probably enter first the Tepidarium, in order not to be exposed suddenly to the heat of the Caldarium, where they were anointed with oil (Celsus I. 3), and it is probable that this was the place generally assigned to that operation, although we read of special *Unctoria*. The anointing with oil took place both before and after the bath; and even after they had already stepped into the bath, they sometimes left it again to be anointed a second time, after which they again betook themselves to the bath. The bathers took the oil with them to the bath (or rather the slave carried it) in phials of alabaster, gold and glass, as well as the *strigiles* or scrapers, and the *lintea*, linen cloths, to dry themselves. In the early days people were content with a simple pure oil, but at a later period costly salves as above described were the fashion. No doubt people anointed themselves at other times besides the bath, in order to reek of perfume the whole day through. (Geneca. Ephist. 86.)

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Even the clothes were anointed with aromatic oils (Jur. III. and Martial VIII. 3, 10).

The luxury and magnificence of the Romans were manifested in the construction of their public baths more than in any other building; they were embellished with *chefs-d'œuvre* of sculpture and painting, and the floors were paved with slabs of marble and inlaid with mosaics. It is estimated that 870 baths were open every day to the public, and rich people possessed private baths of their own, which were even more sumptuous and extravagant in their method of conduction.

The Romans were not acquainted with the use of regular soap, but they employed an alkali, with which the greasy dirt was dissolved out of their clothes. This alkali, called *nitrum*, is referred to by Pliny XXXI. 10; but the cheapest solvent was urine, which was mostly used; the clothes were put in this, mixed with water, and then stamped upon with the feet; this process was performed by old people, whilst boys lifted the clothes out of the tubs. The white garments, after being washed, were subjected to the vapour of sulphur—being stretched on a frame, and the sulphur burned beneath.

Poor people in Rome cleansed their bodies with meal of lupins, called *lomentum*, which, with common meal, is still used in some places for that purpose.

Soap, as we understand the old English word *sope* (from the Greek *sapon* and the Latin *sapo*), was first introduced by the Gauls, who found out a way of making it from goats' tallow and the ashes of beech-wood. This was, no doubt, rather caustic, but it was uncontaminated with colouring matters and the deleterious perfumes put into common soaps of the present day. The soap was made into balls called "Pilæ Mattiaca," named after the town where it was manufactured—"*Mattiacum*" (modernized Marpurg). The French appellation of soap, "savon," seems to be due to a seaport town called Savona, near Genoa, where at a later period, most of the soap for the European market was manufactured.

The Romans, not content with swamping themselves with perfumes at their baths, their toilettes, and their banquets, loved to be surrounded in a perpetual atmosphere of scent, and used, as we use a handkerchief, to dry the perspiration from the forehead, a fine linen cloth called a *sudarium*, saturated with perfume.

THE FACE OF THE SKY FOR OCTOBER.

By Herbert Sadler, F.R.A.S.

SUN-SPOTS and faculæ are still increasing in number. The following are some conveniently observable minima of Algol-type variables (*cf.* "Face of the Sky" for September). Algol.—October 13th, 9h. 48m. P.M.; October 16th, 6h. 37m. P.M. U Ophiuchi.—October 2nd, 8h. 23m. P.M.; October 7th, 9h. 19m. P.M.; October 17th, 10h. 50m. P.M.

Mercury is a morning star during the first half of the month, and is very well situated for observation. He rises on the 1st at 4h. 19m. A.M., 1h. 43m. before the Sun, with a northern declination of 4° 47′, and an apparent diameter of $6\frac{1}{2}''$. On the 4th he rises at 4h. 28m. A.M., 1h. 39m. before the Sun, with a northern declination of 3° 15′, and an apparent diameter of $5\frac{3}{4}''$. About $\frac{74}{100}$ of his disc is then illuminated, and the planet is at its greatest brightness. On the 9th he rises at 4h. 54m. A.M., 1h. 21m. before the Sun, with a northern declination of 0° 2′, and an apparent diameter of $5\frac{1}{2}''$, about $\frac{88}{100}$ of the disc being illuminated. On the 14th he rises at 5h. 24m. A.M., or 1h. 0m. before the Sun, with a southern declination of 3° 35′, and an apparent diameter of 5″, about $\frac{94}{100}$ of the disc being illuminated. After that he rapidly approaches the Sun, coming into superior conjunction at 3h. A.M. on the 28th. He is in conjunction with Saturn at 7h. A.M. on the 3rd, being about 12′ south, the two planets, at 5h. A.M., presenting the appearance of a double star to the naked eye, Mercury, however, being markedly brighter than Saturn. This will be a very interesting spectacle, as Mars will be situated about 5° W.N.W. of the two planets, while Mercury and Saturn are about 3° N.W. of β Virginis. Mercury is at that time distant from the Earth about $99\frac{3}{4}$ millions of miles, Mars $237\frac{1}{3}$ millions of miles, and Saturn $963\frac{1}{2}$ millions of miles. While visible, Mercury pursues a direct path in Virgo, without approaching any very conspicuous star. Venus is invisible, and the same, for the purposes of the observer, may be said of Mars, as his apparent diameter, at the end of the month, does not exceed $4\frac{1}{4}''$.

Jupiter is still the conspicuous ornament of the evening sky. He sets on the 1st at 3h. 28m. A.M., with a southern declination of 9° 14′, and an apparent equatorial diameter of 48″. On the last day of the month he sets at 1h. 19m. A.M., with a southern declination of 9° 48′, and an apparent equatorial diameter of $44\frac{1}{2}''$. The following phenomena of the satellites occur before midnight, while Jupiter is more than 8° above and the Sun 8° below the horizon. On the 1st a transit egress of the first satellite at 7h. 31m., and of its shadow at 8h. 10m.; an occultation disappearance of the second satellite at 9h. 1m. On the 3rd a transit egress of the second satellite at 6h. 49m., and of its shadow at 8h. 11m. On the 5th an occultation disappearance of the third satellite at 7h. 3m. On the 6th a transit ingress of the fourth satellite at 11h. 44m. On the 7th an occultation disappearance of the first satellite at 9h. 50m. On the 8th a transit ingress of the first satellite at 6h. 59m., and of its shadow at 7h. 47m.; a transit egress of the satellite at 9h. 17m., and of its shadow at 10h. 5m.; an occultation disappearance of the second satellite at 11h. 19m. An eclipse reappearance of the first satellite at 7h. 22m. 12s. on the 9th. On the 10th a transit ingress of the second satellite at 6h. 17m., and of its shadow at 7h. 57m.; a transit egress of the same satellite at 9h. 9m., and of its shadow at 10h. 49m. On the 12th an occultation disappearance of the third satellite at 10h. 30m. On the 14th an occultation disappearance of the first satellite at 11h. 38m. On the 15th an eclipse reappearance of the fourth satellite at 5h. 58m. 52s.; a transit ingress of the first satellite at 8h. 46m., and of its shadow at 9h. 42m.; a transit egress of the same satellite at 11h. 4m., and of its shadow at midnight. On the 16th an occultation disappearance of the first satellite at 6h. 5m. P.M.; a transit egress of the shadow of the third satellite at 7h. 31m. P.M.; an eclipse reappearance of the first satellite at 9h. 17m. 43s. On the 17th a transit egress of the shadow of the first satellite at 6h. 29m.; a transit ingress of the second satellite at 8h. 39m., and of its shadow at 10h. 35m.; a transit egress of the second satellite at 11h. 32m. On the 19th an eclipse reappearance of the second satellite at 7h. 37m. 49s. On the 22nd a transit ingress of the first satellite at 10h. 34m., and of its shadow at 11h. 38m. On the 23rd a transit egress of the fourth satellite at 7h. 7m.; of a transit egress of the third satellite at 7h. 16m.; an occultation disappearance of the first satellite at 7h. 53m.; a transit ingress of the shadow of the third satellite at 8h. 10m.; an eclipse reappearance of the fourth satellite at 11h. 31m. On the 24th a transit ingress of the shadow of the first satellite at 6h. 6m., a transit egress of the satellite itself at 7h. 26m., and a transit ingress of the second

satellite at 11h. 3m. On the 25th an eclipse reappearance of the first satellite at 5h. 42m. 15s. On the 26th an eclipse reappearance of the second satellite at 10h. 14m. 18s. On the 30th a transit ingress of the third satellite at 7h. 27m.; an occultation disappearance of the first satellite at 9h. 43m.; a transit egress of the third satellite at 10h. 54m. On the 31st a transit ingress of the first satellite at 6h. 51m., and of its shadow at 8h. 2m.; a transit egress of the satellite at 9h. 10m., and an occultation disappearance of the fourth satellite at 9h. 20m. During the month Jupiter describes a very short retrograde path in Aquarius, but without approaching any naked-eye star.

Saturn does not rise before midnight, and Uranus is in conjunction with the Sun on the 25th. We defer an ephemeris of Neptune till November.

October is rather a favourable month for observations of shooting stars, the most marked shower being that of the Orionids, from the 17th to the 20th of the month, the radiant point of which is situated in 7h. 0m. R.A. and + 15° declination. The radiant point rises at the date named at about 8h. 45m. P.M., and sets shortly after 4 A.M.

The Moon is new at 0h. 58m. A.M. on the 3rd; enters her first quarter at 10h. 57m. P.M. on the 10th; is full at 1h. 45m. P.M. on the 17th; and enters her last quarter at 1h. 56m. P.M. on the 24th. She is in apogee at 9·8h. P.M. on the 1st (distance from the earth 252,600 miles), in perigee at 5·4h. P.M. on the 16th (distance from the earth 222,510 miles), and in apogee again at 4·7h. A.M. on the 29th (distance from the earth 252,300 miles). Her greatest eastern libration is at 2h. 16m. P.M. on the 10th, and her greatest western at 2h. 34m. P.M. on the 22nd.

Chess Column.

By C. D. Locock, B.A.Oxon.

Special Notice to Correspondents.—Till further notice, communications for this column should be addressed "Chess Editor, *Knowledge Office, 326, High Holborn, W.C.*"

Solution of Problem No. 3 (*by C. D. L.*): 1. Kt to B6, and mate's next move.

Correct Solutions from:—Alpha, K, T. E. Kerrigan, J. Landau, W. T. Hurley, M. B. (Jesmond), H. S. Brandretti, Giu. Pianissimo, T. A. Earl, C. T. Blanshard, R. W. Houghton, W. E. B., F. R., E. B., White Knight, R. T. M., C. S., G. F., J. G. Ellis, A. J. Luisham, Betula, A. Rutherford, T., and J. Taylor—(23 all correct).

Alpha.—After 1. . . QQ5, 2. KtB3 is not mate. You also curiously give 2. QB5 in reply to 1. . . QK5. There is another variation, 1. . . QB7, 2. KtQ3.

W. T. Hurley.—Duals following purposeless defences are no defect. In the present case, considering the freedom of the Black Queen, it seems surprising that there are not more.

T. A. Earl.—Positions may be diagrammed by means of either (1) rubber stamps and coloured inks, or (2) coloured pencils, or (3) circles round letters representing black pieces, *e.g.*, (P)=Black Pawn.

Giu. Pianissimo.—Certainly it is easy: but no two-movers are difficult.

White Knight.—As this column goes to press on the 12th of each month, extension of time is an impossibility. Reply to you last month was sent with proofs.

T. H. Billington.—You did not merely claim "no solution." You *assumed* the mistake, and sent in a solution, by which you had to be judged.

Betula.—The Bishop variations are not new, but they are certainly no defect, except for the fact that they have no connection with the key-move. The duals with the Knight are also harmless.

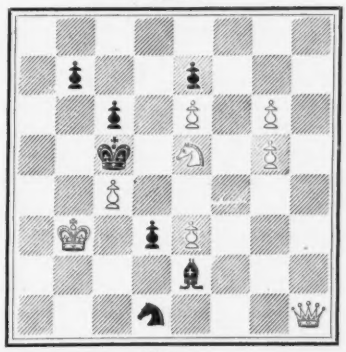
A. J. Luisham.—Every competitor had three courses open—(1) Simply to claim "no solution," (2) To write for information, (3) To take for granted the very obvious misprint, and send solution accordingly. Merely ignoring the problem is not sufficient.

C. T. B.—*Apropos* of "Chess on the brain," did you notice that your three-mover (No. 42) in the *Liverpool Mercury* is a rudimentary picture of your initials?

PROBLEM (No. 4).

(From a Foreign Paper.)

Black.



White.

White to play, and mate in three moves.

Special Notice.—Solvers are particularly requested (1) To read the notice at the head of this page; (2) To send, in addition to White's second moves, the moves of Black which compel them.

Leading Solvers' Scores.

Alpha	14	M. B. (Jesmond)	14
W. E. B.	14	C. T. Blanshard	14
T. E. Kerrigan	14	R. T. M.	14
W. T. Hurley	14	J. Landau	14
K.	14	A. Rutherford	14
Giu. Pianissimo	14	T.	14
T. A. Earl	14	J. Taylor	14
F. R.	14	Betula	10
R. W. Houghton	14	A. C. L. Wilkinson	9
G. F.	14	A. J. Luisham	6
E. B.	14	J. G. Ellis	6
C. S.	14	White Knight	6

Game at odds of Pawn and two moves. (Played at Liverpool last August.)

White (G. F.)	Black (J. E. P.)
[Remove Black's KBP.]	
1. P to K4	1. . . . .
2. P to Q4	2. QKt to B3 (*a*)
3. B to Q3	3. P to K4 (*b*)
4. P to Q5	4. QKt to K2
5. P to KB4	5. P to Q3 (*c*)
6. P×P	6. P×P
7. KKt to B3	7. B to Kt5 (*d*)
8. Castles	8. Q to Q3
9. B to K3!	9. P to QR3 (*e*)
10. Q to K2 (*f*)	10. KKt to B3
11. Kt to B3 (*g*)	11. P to KKt3 (*h*)

12. QR to Qsq (*i*)	12. B to Kt2
13. P to QR3 (*j*)	13. Castles (KR)
14. P to QKt4 (*k*)	14. Kt to Ksq (*l*)
15. P to R3 (*m*)	15. B × Kt
16. R × B	16. R × R
17. Q × R	17. Q to KB3
18. Q to Kt3 (*n*)	18. Kt to Bsq
19. B to KKt5 (*o*)	19. Q to Q3
20. R to KBsq	20. Q to Q2 (*p*)
21. P to Q6 (*q*)	21. Q × P (*r*)
22. Kt to Q5	22. P to B3 (*s*)
23. Q to B3	23. Q to Q2 (*t*)
24. B to B4 !	24. P × Kt (*u*)
25. B × Pch	25. K to Rsq

White mates in three moves.

Notes.

(*a*) Not so good as P to Q3. For White should now continue with 3. P to Q5, Kt to K4 ; 4. P to KB4.

(*b*) Kt × P would obviously lose a piece ; but the best defence again is P to Q3, for the Knight could now capture the Bishop if attacked twice by the Pawns.

(*c*) Forced now ; for if Kt to Kt3, White simply changes Pawns and checks with the Queen, followed by P to K5.

(*d*) Obviously preparing to Castle on the Queen's side,—a plan which he never carries out. Kt to Kt3 seems preferable.

(*e*) He dare not Castle on account of 10. B × P, P to QKt3 ; 11, B to R6ch, K to Q2 ; 12. Kt × P, Q × Kt ; 13. Q × Bch, K to Ksq ; 14. B × P ! and wins.

(*f*) So far White has played excellently, and has in fact a winning position. But now he begins to indulge in a series of weak moves which partly justify the odds received. QKt to Q2 would at once increase his advantage.

(*g*) Again, QKt to Q2 would be much better.

(*h*) Black now prepares Castling on the other side ; perhaps he would do so better by Kt to Kt3 and B to K2.

(*i*) Owing to the weak position of his Queen's Knight, White gains nothing by 12. Q to B2, B × Kt ! (if 12. . . . B to Kt2 ; 13. Kt × P, Q × Kt ; 14. B to Q4) ; nor by 12, P to KR3, B × Kt ! (if 12. . . . B to Q2 ? ; 13. Q to B2 ! threatening both B to B5 and Kt × P). He might play 12. Kt to Qsq.

(*j*) Now perhaps 13. Kt to Ktsq is the most promising course, with a view to Kt to Q2 or P to QB4.

(*k*) This greatly weakens the Queen's side, and leaves the Knight undefended. Again, Kt to Ktsq seems best.

(*l*) Kt to R4 seems much better, and would render the subsequent slaughter unnecessary.

(*m*) A wasted move. Kt to Ktsq with a view to P to QB4 is still best.

(*n*) Q to Kt4 is probably better. Q × Q is also good enough.

(*o*) R to KBsq should be played at any rate first.

(*p*) If White's reply is sound he should play something to KB3 instead.

(*q*) Ingenious, if not quite sound. The safest course was Kt to Qsq and Kt to K3.

(*r*) Kt (from Ksq) × P was also feasible. If then 22. Kt to Q5, P to B3 ; 23. Kt to B6ch, B × Kt ; 24. B × B, Kt to B2 (if Kt × P ? 25. B to B4ch), and Black has good chances of drawing.

(*s*) He had still a good resource in Kt to Kt3.

(*t*) Q to Bsq. is the only defence. White then recovers the Pawn by exchanging and checking with the Knight.

(*u*) Fatal. But if K to Rsq ; 25. Kt to Kt6 wins, as "G. F." points out. The ending is very well played by White.

KNIGHTS AND BISHOPS.

(*Concluded from p.* 180.)

9. There is one other advantage of the Bishop, incidentally mentioned under Point 4, which deserves a separate heading. This is the power of advancing or retreating, when attacked, *without being diverted from its purpose*. When a Knight is compelled to move, its range of attack is entirely altered.

To sum up the results of this not very scientific investigation, it appears that the Bishop has the advantage in six points out of the nine. Curiously enough no less than three out of these six points are applicable only, or, at any rate, specially, to the end-game—the very stage in which the Knight is supposed to assert its superiority. It is necessary to assume, therefore, that in the end-game, Point 2 is so important as to outweigh Points 5, 6, and 7. And this may well be the case. Winning Pawns is the essential point in an end-game, and in this the Knight's superiority is unquestioned.

Taking only the opening and middle game into consideration (and omitting, therefore, points 5 and 6), the Bishop has the best of four points out of the remaining seven ; a result in accordance with its generally estimated value. This, of course, is only a coincidence ; a merely numerical statement of advantages does not amount to proof. [Notice that Point 7 is not omitted. Though a Bishop can only *totally* confine a Knight in the end-game, a *partial* confinement is of constant occurrence early in the game. For instance, a Bishop at K3 may be said to partially confine a Knight at K3. It guards four squares attacked by the Knight, and though the Knight also guards four squares attacked by the Bishop, the Bishop can move *beyond* the Knight's range, past the guarded squares]. The combinations of minor pieces must be briefly dismissed. Two Bishops are stronger than Bishop and Knight, which, again, are superior to two Knights. Two Bishops can mate easily, Bishop and Knight with difficulty, two Knights not at all. Two Bishops can also prevent a King from crossing the board, even more effectually than a Rook. When placed side by side the King cannot even approach them.

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